IMMEDIATE IDENTIFICATION AND CORRECTION OF ERROR IN A COMPLEX PSYCHOMOTOR TASK --TYPEWRITING--

by

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ABSTRACT

This study was an attempt to illustrate the relationship between augmented feedback with and without an opportunity for remedial practice and the learning and performance of students from a beginning skill subject--typewriting. Augmented feedback supplied additional information which was removed later without loss of efficiency.

The original statistical design took account of only the final two observations and although these results failed to achieve a statistically significant difference, the results were in the anticipated direction and sufficient to reach the 85% level of confidence. A revised statistical design which made fuller use of the available data and was more realistic in acknowledging the essentially ordinal nature of typewriting scores permitted rejection of the null hypothesis ($p < .01$). The hypothesis postulated for this study was accepted. It states:

> Novice typists supplied with immediate knowledge of error and remedial practice will experience greater gains in learning and performance than an equivalent control group which does not receive immediate knowledge of error and remedial practice.

A partial treatment was incorporated into this design to ascertain if only knowledge of error would be as effective as knowledge of error and remedial practice. There is a strong indication that the knowledge plus practice group was superior to the knowledge only group; the results however are inconclusive ($p < .10$).

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CHAPTER I

INTRODUCTION AND PLAN OF THE PAPER

The following investigation concerns an attempt to apply psychological principles from learning theory to a practical classroom situation. The area chosen for the experiment is the psychomotor process of typewriting; the specific psychological topic under investigation is knowledge of results or feedback.

Introduction

Feedback ordinarily received by an organism is in the form of tactile, kinaesthetic, auditory, and visual feedback. Novice skill learners are unable to make the fine discriminations necessary for efficient utilization of the many sensory cues impinging on the organism. Often they do not realize when they have made an error in typewriting. Therefore, deliberate feedback in the form of augmented visual cues will be incorporated into the skill task to ensure the novice learner receives precise knowledge when an error has been made. With an opportunity to practice the correct sequence where the error occurred, the learner should be able to pay particular attention to the critical movements and thus integrate the correct sequence of cues into the skill structure. Successful integration will enable the learner to make finer discriminations which are crucial for improvement. The remedial practice, which should reduce tension if that sequence is encountered again, will promote efficiency.

The paucity of research dealing with the typewriting process forced the experimenter to rely heavily on the pertinent literature from psychology, in particular that dealing with the psychomotor process of learning. The bulk of research reviewed lends support to the contention that knowledge of results given immediately improves learning. Although this study is not a comparative study of current practices and some hypothesized theoretical approach, it should be mentioned that in normal typewriting drill, an error will often go unnoticed until a proof-reading of the copy locates and identifies this error. This is particularily true for novice typists; however, an expert typist develops such precise sensory accuity, that immediately a mistake is made, the expert will acknowledge such mistake.

Underlying the assumptions above was a desire to construct a typewriting laboratory for students with particular difficulties which they seemed to experience consistently. Special electronic equipment capable of verifying any given drill exercise could be used to signal the typist immediately an error was made. The construction of this equipment involved an electric keyboard synchronized with a paper-tape reader. However, due to the prohibitive cost, it was decided that the principles involved should be put to a scientific test. The actual experiment then was concerned with the feasibility of constructing such school equipment as described above as well as with testing the critical theoretical hypothesis which will be stated in a later section.

Plan of the paper

The following sections of this paper will include a review of the literature and statement of the hypothesis. A theoretical discussion which utilizes a theory of adjustive behavior will attempt to present a conception of the typewriting process and how feedback may be utilized to improve instruction. The research design, both experimental and statistical will be followed by a presentation of the results and a discussion thereof. The implications of this study together with some speculative comments will be included within the discussion of results section. A short summary will conclude the paper.

CHAPTER II

REVIEW OF THE LITERATURE AND STATEMENT OF HYPOTHESIS

Feedback is a concept which is crucial to any discussion of learning. Feedback supplies information regarding the extent, speed, and quality of any response--thus control becomes a function of negative feedback. Knowledge of results is a form of feedback, specifically, knowledge which an individual receives relating to the outcome of a response and supplied in the case of the present study by augmented visual cues.

Review of the literature

Feedback is the strongest most important variable controlling performance and learning (Bilodeau and Bilodeau, 1961). Gagne (1959) considers repetition with reinforcement the most important factor for acquisition of motor skills. Jensen (1955-56) theorizes that practice provides knowledge of results which is somewhat analogous to Annet and Kay's (1957) statement that performance might be improved if subjects attended more to learning to correct past errors than to modifying present activities. Smith (1962) stresses the importance of immediate feedback as opposed to feedback with any delay interval for learning, while Stroud's (1942) discussion of the role of practice in learning emphasizes the necessity for practice at the point of error. Knowledge of results facilitates improvement as the learner is able

to make finer response discriminations (Ammons, 1956), and the augmented cues which lead to these finer discriminations may be removed without loss of efficiency when they become redundant to the learning process (Annet and Kay, 1957).

A review of the experimental literature dealing with the psychomotor process lends itself to classification into five major areas. These five areas will be identified and the major supporting evidence will be cited.

Area (1). Knowledge of results increases the rate of improvement on new tasks. Several investigators (Bilodeau, Bilodeau, and Schumsky, 1959; Ewell and Grindley, 1938; Keller, 1943; Keller, 1945; Lavery and Suddon, 1962; Lindahl, 1945; MacPherson, Dees, and Grindley, 1948-9; Payne and Hauty, 1955; Pressey, 1950; Reynolds and Adams, 1953; Smode, 1958) provide support for this major area.

Area (2). Knowledge of results increases performance on overlearned tasks (Lindahl, 1945; McGuigan, 1959; MacPherson, Dees, and Grindley, 1948-9; Reynolds and Adams, 1953; Trowbridge and Cason, 1932).

Area (3). Knowledge of results has a motivating effect on learning and performance. Most of the evidence in this major area is based on the subjective impressions of the experimenters (Ewell and Grindley, 1938; Little, 1934; MacPherson, Dees, and Grindley, 1948; Payne and Hauty, 1955; Pressey, 1950; Reynolds and Adams, 1953, Smode, 1958).

Area (4). The amount of learning and performance is directly proportional to the schedule of knowledge of results (Bilodeau, 1955; Bilodeau and Bilodeau, 1958(a), 1958(b); Bilodeau, Bilodeau, and Schumsky, 1959; Bilodeau and Ryan, 1960; Bourne, 1957; Brackbill, Bravos, and Starr, 1962; Brackbill and Kappy, 1962; Ewell and Grindley, 1938; Greenspoon and Foreman, 1956; Lavery and Suddon, 1962; Little, 1934; Lorge and Thorndike, 1935; Michael and Maccoby, 1953; McGuigan, 1958; Payne and Hauty, 1955; Reynolds and Adams, 1953; Smode, 1958; Trowbridge and Cason, 1932).

Area (5). Interference with knowledge of results has deleterious effects on learning and performance (Held, 1965; Held and Freedman, 1963; Judd, 1905; McGuigan, 1959; Neumann and Ammons, 1957; Payne and Hauty, 1955; Smith, 1962).

As this study is specifically concerned with the manipulation of knowledge of results for a task that is new--drill material not previously typewritten--only Area (1) investigations will be reviewed. The psychologists investigating this problem have utilized a variety of conditions and apparatus. Pulling a manual lever the proper distance was investigated by Lavery and Suddon (1962) and by Bilodeau and Bilodeau (1958(a). Pressing a key for a specified time was used by MacPherson, Dees, and Grindley (1948). The Pressey (1950) and Keller (1943, 1945) experiments utilized a punchboard scoring apparatus and a Morse key apparatus respectively. Coordinated movements of limbs were required by Ewell and

Grindley (1938) and Lindahl (1945) while various tracking tasks were used by Smode (1958), Reynolds and Adams (1953), and by Payne and Hauty (1955). The data from these experiments is consistent in supporting the view that knowledge of results increases the rate of improvement early in the performance of a new task.

The present study is designed as a preliminary investigation of typewriting which utilizes the opportunity to immediately identify and correct errors. From the review of the literature, it would seem that augmented cues properly interpreted by a subject will increase performance. Stroud's (1942) theoretical discussion centres around the desire to use practice as a device to reinforce the correct sequence of movements. Repetition of specific sequences occurs at the point where errors are made, thus drill material becomes more meaningful. The point stressed by Smith (1962) is the necessity of immediate feedback if such feedback is to be put to the most efficient use.

Hypothesis

This study was designed, then, to test the following specific hypothesis:

Novice typists supplied with immediate knowledge of error and remedial practice will experience greater gains in learning and performance than an equivalent control group which does not receive immediate knowledge of error and remedial practice.

The study was also designed to ascertain if further investigation is warranted respecting the feasibility of constructing a typewriting laboratory.

Definition of Terms

Novice typists. Students enrolled in first-year typewriting and having received seven and one-half months instruction.

Immediate knowledge of error. Notification of error is achieved by extinguishing a signal light placed immediately above the drill exercise being typed. Normally the light is extinguished when subject has typed two or three strokes past the error.

Gain in learning and performance. The achievement score for a subject consists of the net words typed per minute as determined by the International Typewriting Contest Rules.

CHAPTER III

THEORETICAL ORIENTATION

The psychomotor act is very complicated behavior, therefore, an attempt will be made to indicate how the various component parts of this process are integrated to permit display of skill. Because feedback becomes crucial to skill learning, it is proposed to use Coleman's (1960, p. 187) model of the adjustive process which relies upon feedback as the mechanism that corrects behavior which has deviated from the required norm. This model explains with facility the complex perceptual-cognitive-motor event with feedback providing the dynamic element for the model. A diagram of the relationship between feedback and the other component parts is presented in Figure 1.

If this theoretical model is applied to the specific process of typewriting, the drill material is the input or stimulation from the field. The perception component is the selection and organization of the input from the field together with an awareness of meaning. Evaluation will consist of the possible courses of action, and selection will be the choice from among alternatives. Output will consist of muscle movements which operate the typewriter. This process applies to individual keys at the lower levels of skill mastery, letter combinations at a more advanced level, and complete words and phrases at a still higher level.

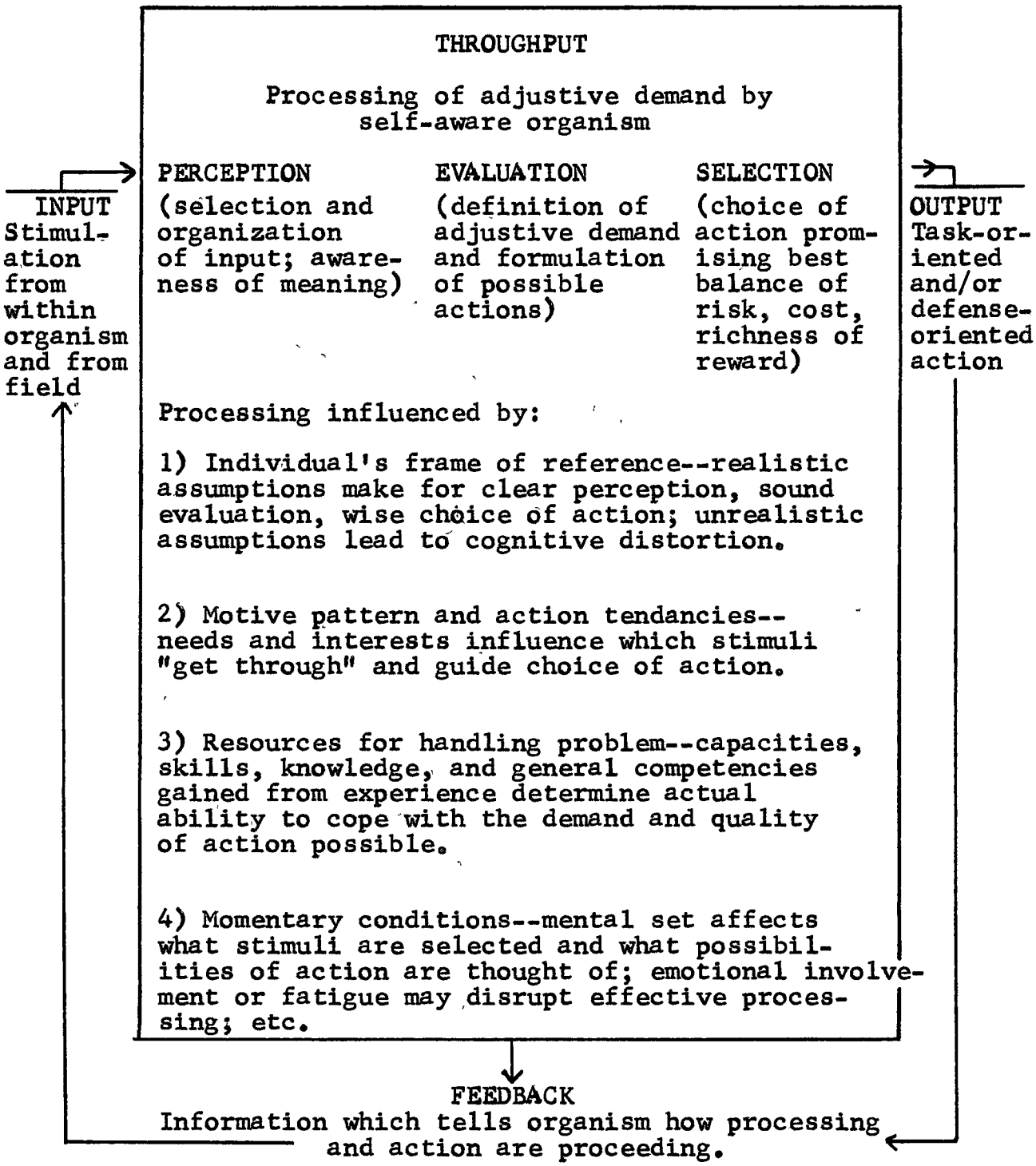

FIGURE 1

ADJUSTIVE BEHAVIOR (From Coleman, 1960, p. 187)

Feedback received by the organism is in the form of tactile, kinaesthetic, auditory, and visual feedback. Because of the difficulty in controlling these variables only deliberate feedback will be added to the experimental design in an attempt to augment the other forms already available to the novice typist. As this deliberate feedback is by means of a light being extinguished, it will utilize the visual sense and give notification of error to the skill learner as soon as possible after an error has been committed. With an opportunity to practice the correct sequence where the error occurred, the typist should be able to pay particular attention to these crucial movements and thus integrate the proprioceptive cues available into their existing skill structure. This will permit the organism to acquire a finer mechanism for discriminatory purposes.

This general apparatus permits the input--symbols from the printed copy--to act upon the organism producing sensations. In an intelligent organism these sensations are recognized and result in a planning of action on the part of the organism. A decision which arises from a judgemental process activates the motor producing portions of the organism resulting in output of a response--operation of the typewriter. Each bit of the response is fed back to the organism by the sense organs. In this experiment, additional information is received when a typewriting error occurs and an opportunity is provided to permit practice of the proper

sequence of finger movements. This remedial activity will allow the novice an opportunity to integrate the proprioceptive feedback available from the practice session into her cognitive system.

CHAPTER IV

RESEARCH DESIGN

Experimental

Twenty-four female students were arbitrarily selected by the administration of Eric Hamber Secondary School. All students were enrolled in Typewriting I classes and had received seven and one-half months instruction. The mean age of the subjects was fifteen years, four months; the mean Otis (AM) IQ was 105. No attempt was made to match subjects on any variable except their Easter typewriting rate. This was accomplished by use of a random block design (Edwards, 1960) which ensured greater homogeneity between treatment groups at the start of the experiment. The results of this procedure are located in Appendix A. Age and IQ are included for comparative purposes.

Each subject underwent twenty observations for purposes of data collection. An observation consisted of an eight-minute period comprised of a five-minute drill period; a one-minute rest period; and a two-minute test period. During the test period the experimental equipment which provided treatment effects was removed. All subjects used typewriters with which they were familiar--the Underwood touch-master FIVE--at three-position adjustible typewriting desks. Six error lights permitted the simultaneous observation of six subjects at any one sitting. The observers were fellow

students who were also taking part in the experiment. Each subject had a variety of observers including the experimenter during the twenty observation periods.

The error lights consisted of a radio pilot light mounted in a large Bulldog paper clip. A silent switch which could be operated by the observer who was watching the subject type was connected to the pilot light by a two-conducter wire seven feet long. Thus the observer did not interfere with the subject undergoing the observation. Power supply for the lights was from a six-volt bell transformer. The total cost of equipment used to construct the six error lights was less than twelve dollars.

The observations were carried out in a small business machines room at the school. Room dimensions were fifteen by thirty feet; the equipment in the room consisted of fourteen typewriters, two tables, several chairs, and two additional pieces of office equipment. Exclusive use of this room was impossible, however, other students using the room did not interfere with the experimental subjects. In fact, the additional activity in the room more nearly approximated the actual classroom conditions of their normal typewriting class. The timing of the observations was by stop-watch operated by the experimenter. The treatment variations to be described below were applied only during the five minute drill period. Prior to the start of the experiment, a brief explanation was offered to the students concerning the

nature of research.

Treatment 1 (Augmented Practice Group). An error made during the drill period resulted in the observer extinguishing the error light after subject had typed two or three strokes past the error. One line of corrected sequence was typewritten immediately, then the drill was resumed at a point in the copy immediately following the error. Printed instructions prepared by the experimenter were supplied to each subject which indicated to each group what action to take if the error light went out. The instructions supplied to Augmented Practice Group follow:

> If the signal light goes out--STOP--locate your error, return carriage, and type one line of corrected sequence. After completion, return carriage and resume typing at point in copy immediately following error.
> If error is located in a five-stroke word or under, the line of correct sequence will include the word immediately preceeding the error plus the word that contains the error. If error is located in a word over five-strokes, the line of correct sequence will consist of only the word which contains the error.

Treatment 2 (Augmented Group). An error made during the drill period resulted in the observer extinguishing the error light after subject had typed two or three strokes past the error. The drill was resumed after the subject had made a mental note of the error. No opportunity was permitted for correction of the error. The printed instructions supplied to the Augmented Group are reproduced below:

> If the signal light goes out--STOP--locate error and make a mental note to try to avoid this error in the timed-writing that follows.
> Resume typing.

Treatment 3 (Control Group). The Control Group had the same drill material, took the same timed-writings, and were subjected to the same forms of experimental manipulation as the other groups. Although observers stood behind the Control Group extinguishing the error lights at random--four to five times during a five-minute drill period--there was no identification and correction of error during the drill period. The instructions supplied to the Control Group are reproduced below:

> Type practice material for five-minutes using correct techniques. The signal light will have nothing to do with your typing.

After completion of the drill period, all groups then had a one-minute rest period which was used to remove the experimental equipment and ensure the observers were not standing behind the subjects. It also permitted an inspection of the drill material which had been typewritten by all groups. The two-minute test period consisted of a timed-writing on the drill material that each individual subject had previously been practicing. The material used for this purpose consisted of Underwood Typing Tests, Volume 4, Numbers 1 to 4 inclusive. Each observation concentrated on a particular paragraph which the subject had not previously encountered.

Statistical

It had originally been planned to analyze the data from only the final two observation periods as the belief was that the greatest difference between mean scores would be at that point. It was later realized that a mode of analysis that would

take fuller account of all of the data would be more appropriate. Accordingly both statistical designs were used to interpret the data.

Original design. The comparison of means between the Augmented Practice Group and the Control Group--the hypothesis postulated deals specifically with this comparison--utilized a "t" test following the method specified by Hays (1963, p. 474). This particular technique requires the sum of squares for a comparison and is obtained by removing the sum of squares for the Augmented Practice Group and the Control Group from the treatment sum of squares obtained from the random block analysis of variance (Edwards, 1960). The formulas for this process are given below:

$$SS_{1,3} = \frac{(\bar{x}_1 - \bar{x}_3)^2}{\frac{1}{n_1} + \frac{1}{n_3}}$$

$$\text{"t"} = \sqrt{\frac{SS_{1,3}}{MS_{error}}}$$

Because there is an Augmented Group included in this design, it had been proposed to find if the residual sum of squares yielded a significant F ratio. This test (Hays, 1963, p. 478) indicates if there is any other significance to the data. A significant F ratio would indicate that there was still some variability among means other than between the Augmented Practice Group and the Control Group. Since the

remaining comparisons of interest--Augmented Practice Group with Augmented Group and Augmented Group with Control Group--were not orthogonal to the first comparison or to each other, it had been planned to use a conservative technique by treating the data as unplanned comparisons and using the Tukey(a) procedure (Winer, 1962, p. 87).

Revised design. While collecting the data for this experiment, it became apparent that the mean scores from the Augmented Practice Group were markedly and consistently superior to those of the Control Group. Basing the results of this study on observations nineteen and twenty, not the bulk of the data collected, placed all confidence for the experimental results on too narrow a sample of performance when data from twenty learning sessions was available. It should have been realized earlier that a more adequate statistical design would have taken account of this. The hypothesis which predicted that the Augmented Practice Group would experience greater gains in learning and performance was concerned with the consistency of the results as well as with the absolute difference between the two groups. Because typewriting scores have the characteristics of ordinal measurement, a non-parametric technique was used to analyze trend. The first four observations were arbitrarily eliminated from the test while the last sixteen were analyzed by the Wilcoxon matched-pairs signed-ranks test (Siegel, 1956, p. 75) This particular test took account of the relative magnitude as well as the

direction of the difference.

The mean scores from each of the treatment groups were plotted graphically for comparative purposes. Separate graphs for gross words per minute and for net words per minute are presented in Appendix C and Appendix D respectively, and will be discussed in a later section of this report.

CHAPTER V

RESULTS AND DISCUSSION OF RESULTS

Results

The data from this experiment was composed of 469 timed writings obtained from the participating students over a period of six weeks. Observations nineteen and twenty were pooled to give a more stable picture of the final results. The mean scores for each type of treatment expressed in net words per minute are presented in Table I.

TABLE I

AVERAGE TYPEWRITING RATE FOR OBSERVATIONS NINETEEN AND TWENTY EXPRESSED IN NET WORDS PER MINUTE FOR EACH TREATMENT GROUP

Block	Augmented Practice Group	Augmented Group	Control Group
1	46	48.5	38
2	30.5	25.5	27.5
3	27	46.5	20
4	49.5	25.5	24
5	33	25.5	20
6	27	15	21
7	12	12	33
Total	225	198.5	183.5
Mean	32.14	28.35	26.21

The resulting "t" between Augmented Practice Group and the Control Group was 1.12. This failed to reach the .05 level of significance, however, the results were in the anticipated

direction and sufficient to reach the 85% level of confidence. From the analysis of variance, it was found that the residual sum of squares was not sufficient to warrant further treatment of the data--the a posteriori comparisons which had been planned between the means of the Augmented Practice Group and the Augmented Group and between the Augmented Group and the Control Group. The summary table from the analysis of variance for the final two observations is presented in Table II below.

TABLE II

ANALYSIS OF VARIANCE SUMMARY FOR OBSERVATIONS NINETEEN AND TWENTY

Source of Variation	SS	df	Mean Square	F
Treatment	126	2	63	.63
Block	1252	6	208.6	2.08
Error	1203	12	100.25	-
Total	2581	20		

The results of this experiment when expressed as gain scores are consistent in showing the superiority of the Augmented Practice Group over the Control Group ($p < .15$). The increase in net words per minute was calculated by subtracting the net Easter typewriting rate from the average of observations nineteen and twenty; Table III presents the

results of these calculations.

TABLE III

GAIN SCORES EXPRESSED IN NET WORDS PER MINUTE OBTAINED BY COMPARISON OF POOLED OBSERVATIONS NINETEEN AND TWENTY WITH NET EASTER TYPEWRITING RATE

Treatment Condition	Easter Rate	Average of Ob's 19 & 20	Gain
Augmented Practice Group	26.71	32.14	+5.43
Augmented Group	25.71	28.35	+2.64
Control Group	26.28	26.21	- .07

The Wilcoxon matched-pairs signed-ranks test (Siegel, 1956, p. 75) which took cognizance of the direction and magnitude of any difference was applied to check the consistency of the data. Only observations five to twenty inclusive were used for this purpose. The mean scores for the three treatment conditions over the twenty observations are presented in Appendix B. The Augmented Practice Group was compared with the Control Group; the resulting T--ranks with less frequent signs--was 21. This was found to be significant in indicating that the Augmented Practice Group demonstrated consistently superior performance on the timed-writings than the equivalent Control Group ($p < .01$). The calculation of T is given below in Table IV.

This technique was also applied to ascertain if the Augmented Practice Group was superior to the Augmented Group. As direction had not been specified beforehand, a two-tailed

test was used. The resulting T of 35 just failed to achieve significance at the .05 level. There is certainly a strong indication that the Augmented Practice Group is superior to the Augmented Group ($p < .10$); however, the data does not unequivocally support this conclusion. Further research appears warranted if this area of doubt is to be resolved. Table V presents calculations for T between the Augmented Practice Group and the Augmented Group.

TABLE IV

DIFFERENCE AND RANKS OF DIFFERENCE OF MEAN SCORES BETWEEN AUGMENTED PRACTICE GROUP AND CONTROL GROUP FOR CALCULATION OF T

Observation	Difference	Ranks of Difference	Ranks with less frequent signs
5	1.875	4	
6	3.75	9	
7	-3.00	-6.5	-6.5
8	2.5	5	
9	3.375	8	
10	6.29	14	
11	3.00	6.5	
12	5.15	13	
13	.14	1	
14	.29	2	
15	-1.14	-3	-3
16	10.86	16	
17	-4.43	-11.5	-11.5
18	3.86	10	
19	7.43	15	
20	4.43	11.5	
			T = 21.0 *

* Significance of T determined from Table G (Siegel, 1956, p. 254).

TABLE V

DIFFERENCE AND RANKS OF DIFFERENCE OF MEAN SCORES BETWEEN AUGMENTED PRACTICE GROUP AND AUGMENTED GROUP FOR CALCULATION OF T

Observation	Difference	Ranks of Difference	Ranks with less frequent signs
5	4.25	10.5	
6	3.50	9	
7	-2.375	-5	-5
8	.50	1	
9	4.25	10.5	
10	9.86	15	
11	6.00	14	
12	-1.85	-3	-3
13	10.14	16	
14	2.43	6	
15	-2.57	-7	-7
16	.58	2	
17	-3.15	-8	-8
18	-4.86	-12	-12
19	5.29	13	
20	2.29	4	
			T = 35 *

* Significance of T determined from Table G (Siegel, 1956, p. 254).

An inspection of the data indicated that there was no possibility of any significant difference between the Augmented Group and the Control Group.

Discussion of results

The results of this experiment permit acceptance of the hypothesis. The Augmented Practice Group made consistently greater gains in learning and performance when compared with an equivalent Control Group which did not receive immediate error identification and an opportunity for practice of the correct

skill sequence. The original statistical design placed all confidence for the experimental results on too narrow a sample of performance considering that data from twenty learning sessions were available. In this design, the planned "t" test between the Augmented Practice Group and the Control Group indicated the former was superior at the 85% level of confidence. A revised statistical design made fuller use of the data available and permitted a more comprehensive analysis. The Wilcoxon matched-pairs signed-ranks test (Siegel, 1956, p.75), which concerned itself with the consistency of the data, as well as the magnitude of the obtained differences between the mean scores, indicated the superiority of the Augmented Practice Group over the Control Group ($p < .01$). It is considered that the revised design is more realistic for two reasons: (1) it takes account of the bulk of the data, rather than of the results of only two trials, and (2) it acknowledges the essentially ordinal character of the data.

One of the theoretical assumptions made earlier was that the students receiving error identification and remedial practice would become much more sensitive to the proprioceptive feedback available. Objective observations by the experimenter support this assumption. Students in the Augmented Practice Group required error notification for the earlier observations, but during the later sessions, these students would stop typewriting instinctively when an error

was made. It would appear that these students had acquired a finer mechanism for discriminatory purposes. Some students in the Augmented Group also displayed this behavior.

Several factors reduced the possibility of obtaining highly significant results on a single observation. Due to time limitations, it was necessary to conduct this experiment during the closing months of the school year. The students who participated in this experiment had eight months experience, obviously with some rather well established habits. Any treatment effect imposed would first have to overcome the established habits before the significance of the treatment would be noted.

The experiment began with an N of twenty-four, but during the course of the experiment, one of the subjects broke her finger. Because this caused elimination of a complete random block, the N was reduced to twenty-one, causing a reduction in the degrees of freedom by three and thus making the statistical tests more rigorous.

Appendix C, the graph depicting mean gross words typed per minute, appears to reflect the relative difficulty of the material being typed. The fluctuations of the Augmented Practice Group and the Control Group are almost identical while the Augmented Group varies between these two.

Appendix D presents the mean net words typed per minute for each individual treatment group and takes into account the number of errors. The superiority of the Augmented Practice

Group can be clearly observed. The general pattern for all three group is one of improvement; however, the steepest slope is found for the Augmented Practice Group while the flatest slope depicts the Control Group. It would appear that a projection of these trends would lead to a significant difference between means for a single observation. This of course is speculation and will require verification by an extended experiment conducted along similar lines.

The results of this experiment would seem to have certain implications for education. Insofar as typewriting is concerned, there is now justification for construction of a typewriting laboratory. Equipment of this nature could be used for further research purposes, to a point where individual drill exercises were prepared for each learning difficulty experienced by individual students in beginning typewriting. The method of error notification employed by this experiment coupled with remedial practice did result in superiority of learning and performance of the Augmented Practice Group. This inexpensive apparatus could be effectively used in any classroom situation if students were matched to work together as observer and typist.

As there is a paucity of research dealing with typewriting theory, it is hoped that this investigation will lead to further research on psychomotor skills employed by students in the business subjects. The limitations previously discussed relating to size of sample and time of school year

should be important if related studies are anticipated. The results of this experiment do indicate a need for further research to clarify the role of notification of error only in contrast to notification of error with remedial practice.

CHAPTER VI

SUMMARY AND CONCLUSION

An attempt was made in the classroom setting to determine the influence of augmented feedback with and without remedial practice in a complex psychomotor task--typewriting. Twenty-four female students enrolled in a first year high-school typewriting class were assigned by a random block procedure to one of three treatment groups. The Augmented Practice Group received error notification and had an opportunity to correct any errors committed; the Augmented Group received notification of error only. The Control Group practiced the drill material in the usual manner; no error notification or practice was permitted. It was hypothesized that the Augmented Practice Group would show significant improvement in learning and performance when compared with the Control Group.

During a six-week period, twenty observations per student were obtained with each observation being composed of an eight-minute period of typewriting--five-minutes drill, one-minute rest, and a two-minute test period. Error lights operated by fellow students who acted in the capacity of observers were used to signal the treatment groups, if required, when an error had been made. The Control Group experienced operation of the error lights, although for this group they had no significance. During the test period, the

error lights were extinguished, and the observers moved from behind the experimental subjects to some other part of the classroom.

Two statistical designs were used to interpret the data obtained from this experiment. The original "t" test between the means of the Augmented Practice Group and the Control Group which was obtained from the final two observations yielded a value of 1.12 which failed to reach the .05 level of significance. The revised Wilcoxon matched-pairs signed-ranks test (Siegel, 1956, p. 75) made fuller use of the data, and was concerned with the consistency of the superiority of one group over another as well as the magnitude of the obtained difference between mean scores. This revised design is more realistic as it considers a much larger portion of the data and acknowledges the essentially ordinal character of typewriting scores. Superiority of the Augmented Practice Group over the Control was found ($p < .01$) which permitted the rejection of the null hypothesis. An attempt was also made to find if the Augmented Practice Group was superior to the Augmented Group. There was certainly a strong indication that this was so ($p < .10$); however, the data does not permit unqualified acceptance.

Generalizations from this experiment are difficult in view of the limited size of the sample used. A matching system of typist and observer would however seem to possess certain merit for students experiencing consistent difficulty

in a specific area of typewriting. There would also appear to now be sufficient justification for the construction of a typewriting laboratory which could be used for the conduct of research in the psychomotor skill area. Electronic equipment capable of verifying a given drill exercise could signal a typist immediately an error was made and thus provide an opportunity for remedial practice. Under the conditions outlined by this experiment, this procedure of error identification and remedial practice has shown its superiority over the normal drill methods.

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A P P E N D I X

APPENDIX A

RANDOM BLOCK PROCEDURE

	Augmented Practice Group				Augmented Group				Control Group			
Block	Subject	Easter Net Rate	Age	I. Q.	Subject	Easter Net Rate	Age	I. Q.	Subject	Easter Net Rate	Age	I. Q.
1	11	38	15-4	115	21	48	14-4	114	31	40	15-3	105
2	12	37	16-6	89	22	32	15-0	113	32	33	14-10	108
3	13	30	14-9	110	23	32	15-0	117	33	32	17-3	103
4	14	29	15-4	96	24	24	14-11	116	34	26	15-3	107
5	15	20	15-11	94	25	25	15-4	98	35	24	14-8	102
6	16	21	14-11	109	26	19	15-9	98	36	18	15-4	93
7	17	18	14-5	122	27	15	16-8	99	37	16	15-5	99
8	18	12	15-7	95	28	0	17-10	115	38	11	14-7	119
Mean (N = 8/Group)		25.6	15-3	103.7		24.3	15-6	108.7		25	15-3	102.6
Mean (N = 7/Group)*		26.7	15.5	101.1		25.7	15.4	110.1		26.3	15-3	103.1

* Block 7 removed due to broken finger suffered by subject #17.

APPENDIX B

MEAN SCORES EXPRESSED IN NET WORDS PER MINUTE

Observation	Augmented Practice Group	Augmented Group	Control Group
1	16.00	18.75	22.875
2	17.625	26.25	21.00
3	20.75	22.375	20.625
4	20.375	21.375	22.25
5	26.00	21.75	24.125
6	27.75	24.25	24.00
7	22.375	24.75	25.375
8	22.75	22.25	20.25
9	29.125	24.875	25.75
10	32.29	22.43	26.00
11	27.14	21.14	24.14
12	26.29	28.14	21.14
13	24.43	14.29	24.29
14	28.43	26.00	28.14
15	18.57	21.14	19.71
16	26.29	25.71	15.43
17	23.14	26.29	27.57
18	28.00	32.86	24.14
19	33.00	27.71	25.57
20	31.29	29.00	26.86

APPENDIX C

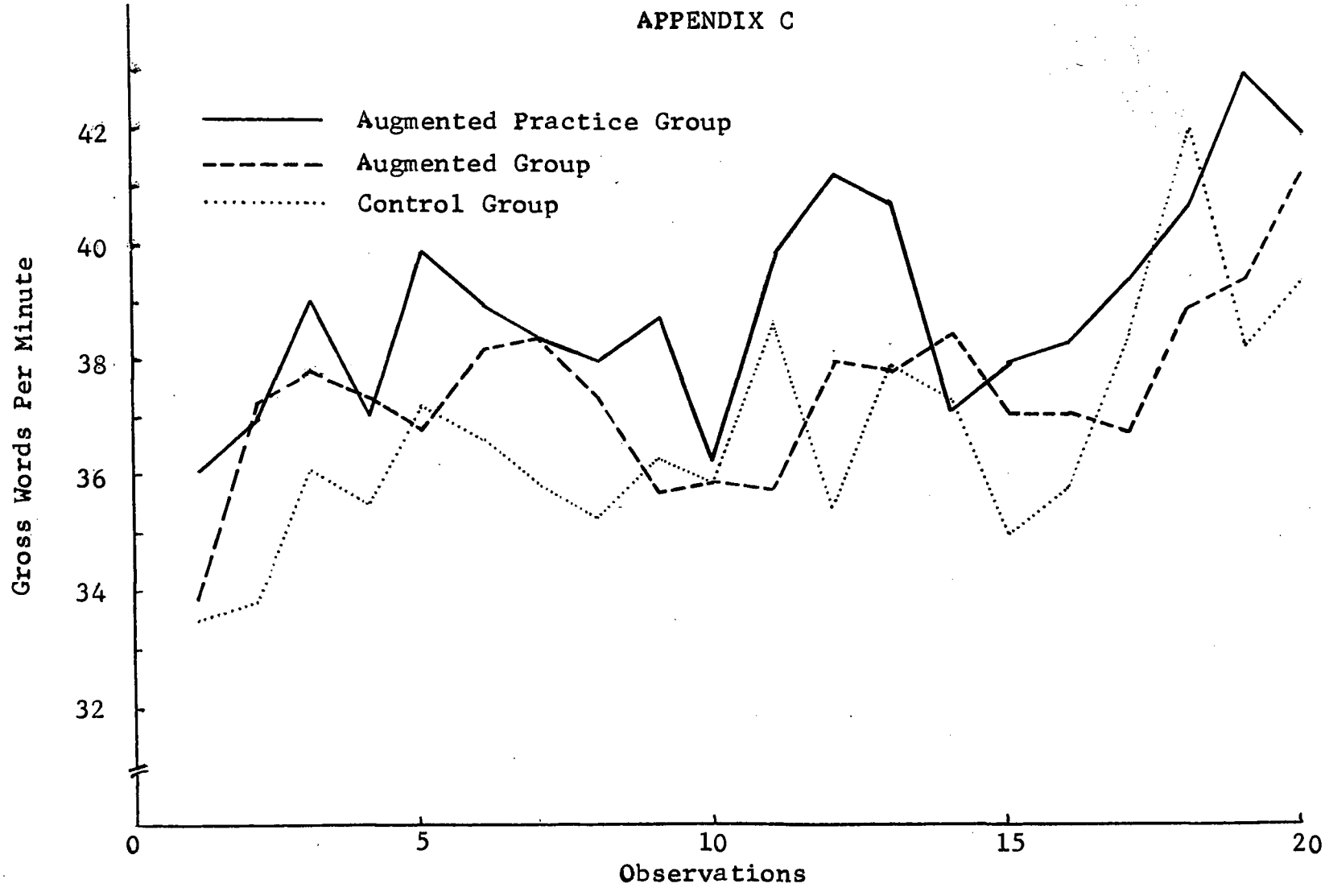

FIGURE 2

GROSS WORDS TYPED PER MINUTE FOR EACH TREATMENT GROUP

APPENDIX D

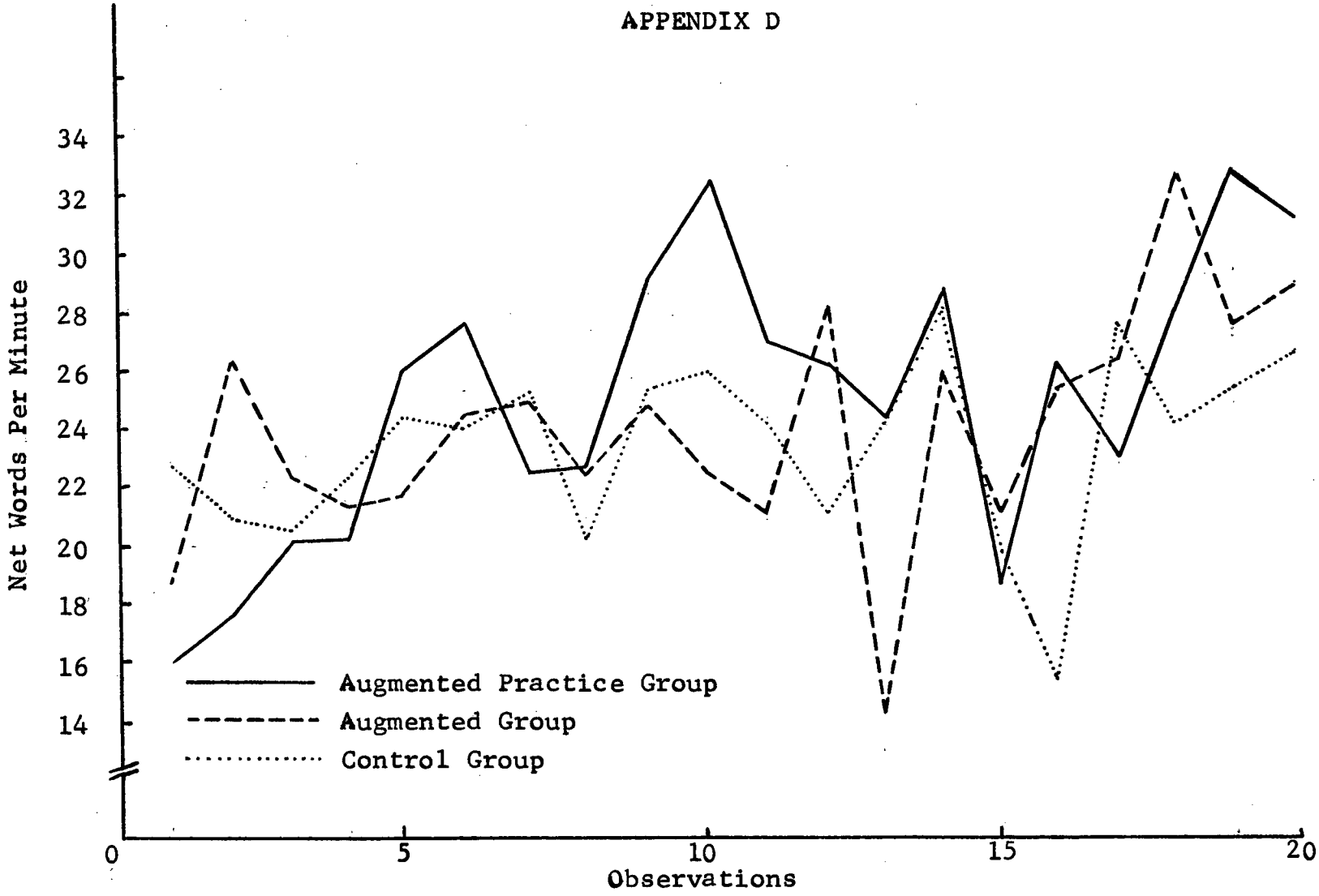

FIGURE 3

NET WORDS TYPED PER MINUTE FOR EACH TREATMENT GROUP