To the Graduate Council:

I am submitting herewith a dissertation written by Gary L. Patrick entitled "The Evaluation of an Optometric Vision Training Program Using a Single Subject Multiple Baseline Research Design." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Psychology.

Richard A. Saudargas, Major Professor

We have read this dissertation
and recommend its acceptance:

Accepted for the Council:

Vice Chancellor
Graduate Studies and Research

Thesis
79b
P387
cop. 2

THE EVALUATION OF AN OPTOMETRIC VISION TRAINING PROGRAM USING A SINGLE SUBJECT MULTIPLE BASELINE RESEARCH DESIGN

A Dissertation

Presented for the

Doctor of Philosophy

Degree

The University of Tennessee, Knoxville

Gary L. Patrick

August 1979

1398080

Copyright by Gary L. Patrick 1979
All Rights Reserved

ACKNOWLEDGEMENTS

I would like to thank the members of my doctoral committee--Dr. Richard A. Saudargas, Chairperson, Dr. Michael Hannum, Dr. Harvey Kaufman, Dr. J. C. Tumblin, Dr. Sandra Twardosz, and Dr. Robert Wahler--for their professional and personal support throughout this project. I am especially indebted to Dr. Saudargas and Dr. Tumblin for their unselfish gifts of time, support, and knowledge.

I want to thank Ms. Debra Wancio for her excellent performance as a research assistant, my wife Sandra for her dedication in scoring reading tapes and preparing graphs, Ms. Jill Prudden for her assistance in obtaining reliability, and Ms. Gail McKinney for her assistance in typing the initial drafts of this project. I also wish to give a special thanks to the parents and students who participated in this study for their support, assistance, and hard work in making this project successful.

Most of all, I would like to thank my wife, Sandra Droster Patrick, and my parents, Edward and Elenore Patrick for their continued support, love, and caring throughout this project and my graduate education.

ABSTRACT

The application of classical large group designs to evaluate the effectiveness of optometric vision training has failed to provide a realistic picture regarding the effects of optometric vision training. For this reason the need for an alternative research methodology was apparent and theoretically the single case experimental research design methodology appeared to better meet the needs of this applied optometric area. A single case multiple baseline experimental design was employed across two elementary school children in an optometric vision training practice in order to measure the effectiveness of a specific optometric treatment package. Over twenty visual, academic, and visual-motor assessment procedures were developed in order to repeatedly measure the effects of vision training over time. Pre-post testing and follow-up questionnaires were obtained to further substantiate the results observed. A five month follow-up was performed to measure the lasting effect of the treatment package. The results of this study indicate the effectiveness of this optometric vision training package to directly train specific functional visual skills involving accomodation, binocularity, fixational abilities, and pursuits and to improve a specific type of visual-motor functioning without directly training the task. These results can be directly attributed to the optometric vision training package with experimental reliability. Follow-up results were variable, with the majority of the treatment effects maintained. Results suggest the appropriateness

of the specific assessment procedures to measure visual skills repeatedly over time. The single case experimental design appears to be an effective methodology for evaluating optometric vision training in an optometric practice.

TABLE OF CONTENTS

CHAPTER		PAGE
I.	INTRODUCTION, PURPOSE, AND RELATED LITERATURE	1
	Literature	1
	Summary	12
	Purpose	13
II.	EXPERIMENTAL DESIGN AND METHODOLOGY	14
	Subjects	14
	Setting	15
	Methods	16
	Standard optometric assessment procedures	17
	Standard optometric training procedures assessed	21
	Academic and visual motor skills assessed	24
	Pre-post assessment procedures	25
	Experimental Conditions	26
	Baseline	26
	Stage I: monocular training	29
	Stage II: biocular/binocular training	38
	Follow-up	47
III.	RESULTS	49
	Assessment of standard optometric training procedures	49
	Standard optometric assessment procedures	68
	Academic and visual-motor skills assessed	81
	Pre-post assessment results	92

CHAPTER PAGE

IV. DISCUSSION. 95

Individual Differences. 98

Delayed effects 99

Questionable instrumentation. 100

Extraneous uncontrolled variables 101

BIBLIOGRAPHY. 106

VITA. 110

LIST OF TABLES

TABLE PAGE

1. Characteristics of Large Group Studies on Optometric Vision Training with Children. 4
2. Results of Controlled Studies Employing Optometric Vision Training Techniques 6
3. Assessment Procedures Employed and Those Procedures Performed by Research Assistant 18
4. Displays the Sequence of Optometric Vision Training Procedures Performed and Changes that Occurred Within These Procedures by Types of Change and the Session the Change Occurred 27
5. Displays the Means, Ranges, and Number of Sessions of Each of the Dependent Measures Employed in Relation to Experimental Condition (Paragraph Reading not Included). 52
6. Results of Assessment Procedures Employed Before and After Optometric Vision Training. 93

LIST OF FIGURES

FIGURE PAGE

1. Reading rate and error percentage of total errors, hesitation errors, and omission errors in each of the experimental conditions of the paragraph reading. 50
2. Percent insertion errors, percent substitution, mispronunciation, and words pronounced by the examiner errors, percent disregard of punctuation errors, and percent repetition errors in each of the experimental conditions of the paragraph reading 51
3. Number of correct responses per minute exhibited by the students in each of the experimental conditions on the Adapted Robbin's Rock 56
4. Number of rotations each student exhibited per session for each of the experimental conditions with either the right or left eye. 57
5. Number of rotations each student exhibited per session for each of the experimental conditions with both eyes. 58
6. Number of correct responses per minute exhibited by the students in each of the experimental conditions on the Space Rock and the percent correct exhibited by the students on the Tachistoscope assessment procedure 59
7. Number of correct responses in a thirty second period each student exhibited while performing the Directionality assessment procedure with regard to experimental condition 60

PAGE

FIGURE

8. Break and recovery points each student exhibited while performing the Quoits Base In and Quoits Base In Recovery assessment procedure with regard to experimental condition. 61

9. Break and recovery points each student exhibited while performing the Quoits Base Out and Quoits Base Out Recovery assessment procedure with regard to experimental condition. 62

10. Number of letters correct per second exhibited by each student on the Binocular Saccadic Fixation assessment procedure while wearing no lenses. 69

11. Number of letters correct per second exhibited by each student on the Binocular Saccadic Fixation assessment procedure while wearing +3.00 lenses 70

12. Number of letters correct per second exhibited by each student on the Binocular Saccadic Fixation assessment procedure while wearing -4.00 lenses 71

13. Number of letters correct per second exhibited by each student on the Binocular Saccadic Fixation assessment procedure while wearing +3.00 and -4.00 lenses 72

14. Percent steropsis scored by each student on the Keystone Aviator Series. 73

15. Scaled scores for the Keystone Visual Skills Lateral Posture assessment procedure for near and far point. 74

16. Percent steropsis scored by each student on the Keystone Visual Skills Stereopsis assessment procedure. 75

FIGURE PAGE

17. Number of correct responses made by each student on the SILO Base 15 Prism assessment procedure throughout the experiment 76

18. Number of letters correct per minute each student scored on the coding task throughout the experiment. 82

19. Reading rate of each student throughout the Paragraph Reading assessment procedures. 83

20. Total percent reading errors for each student throughout the Paragraph Reading assessment procedure 84

21. Hesitation errors and omission errors exhibited by each student throughout the Paragraph Reading assessment procedures . . . 85

22. Insertion errors exhibited by each student throughout the Paragraph Reading assessment procedures. 86

23. Substitution, mispronunciation, and word pronounced by the examiner errors exhibited by each student throughout the Paragraph Reading assessment procedures. 87

24. Disregard of punctuation and repetition errors exhibited by each student throughout the Paragraph Reading assessment procedures 88

CHAPTER I

INTRODUCTION, PURPOSE, AND RELATED LITERATURE

Literature

The purpose of optometric vision training is to mediate vision problems which interfere with learning and other academically related skills. The intent of optometric vision training is not to teach reading or other related educational skills, but to provide a more efficient and effective visual system which the individual can utilize to learn.

Experimentally controlled research with children who obtained optometric vision training in applied settings has concentrated on measuring the effects of vision training on academic performance. Recent reviews of literature on optometric vision training have been performed by Keogh (1973) and Greenspan (1972, 1976, 1978).

Keogh (1973) discussed the difficulties in making comparisons across studies because of the confusion within the available literature. Keogh found the following flaws within the literature:

1. Many studies lack controls for the classic Hawthorne effect (i.e. improvements because of special attention versus specific treatment).
2. Longitudinal and/or follow-up studies are few or non-existent.
3. The use of non-random sampling found in a number of studies indicates sampling bias and reduces the generalization of results.
4. A large portion of the research is based on a small number of cases that are single isolated research efforts.

5. So many techniques are utilized in programs that the particular influences of specific methods are often not retrievable.

6. The program effects of the studies are often unspecified with differential influences of the various techniques, the optional means of presentation uncertain, the length of time necessary for effect unspecified, and the scheduling of treatment variable.

Due to the lack of sound methodology, Keogh concluded that the studies could be considered basically unique. These studies represent a single demonstration of unknown effects on a particular group of children, and therefore cannot be generalized to other children, therapists, or settings. As a result, prediction and interpretation are limited with what appears to be a lack of substantive and comprehensive evidence to make decisions as to program effects of optometric vision training.

In reviews of optometric vision training research (Greenspan, 1972, 1976, 1978) noted the lack of methodological care in past research related to optometric vision training and called for research using a fully scientific model. Greenspan indicated, however, that the results of the reviewed studies taken suggest beneficial effects of optometric vision training. A breakdown of the specific beneficial effects as related to treatment procedures were not mentioned.

A detailed review of the literature by the present author indicates that, for the most part, the following types of experimental designs have been employed to research optometric vision training.

1. Single case history studies.

2. Group case history follow-up studies with no treatment controls.

3. Large group research designs without controls (Pre-post testing).

4. Large group designs with control group, but no controls for the Hawthorne Effect.

5. Large group studies comparing other treatments with optometric vision training, however without controls.

6. Large group comparative studies with controls for improvement of equivalent non-treatment groups.

7. Large group designs with control for Hawthorne Effect and non-treatment groups ("Soloman Design").

Table 1 describes the characteristics of large group studies on optometric vision training with children, that included control groups. The specific research designs employed and the setting in which the research occurred are also included. Studies without control groups are excluded from the table because the minimum requirements for experimental control were not met. An analysis of the studies listed on the table indicates that the majority of the research performed on optometric vision training does not conform with rigorous scientific methodology. Only one of the twelve studies listed was performed in an optometric practice, the other studies taking place in schools. Studies with control groups but not controlling for the Hawthorne Effect include Halgren and McKee (1960), Halgren, Getman, McKee, and Kane (1963), Morgan (1966), Shearer (1969), Jens (1970), Coleman (1972), Friedman (1974) and Weisz (1979).

Table 2 displays the results of the studies outlined in Table 1. These studies suggest that optometric vision training has a number of beneficial effects on a number of academically related areas in comparison

TABLE 1

CHARACTERISTICS OF LARGE GROUP STUDIES ON OPTOMETRIC VISION TRAINING WITH CHILDREN

Authors	Date	Subjects Number E	Subjects Number C	Ages	Setting	Experimental Design	EHT	DOT	Follow-up
Coleman	1972	14	11	2	2	3	?	1 school year	no
Friedman	1974	40	30	3	2	3	?	13 weeks	no
Halgren	1960	31	31	3	2	3	?	10 weeks	no
Halgren and McKee	1960	31	35	2	2	3	100 hours	10 weeks	no
Halgren et al.	1963	30	190	2	2	3	38 hours	15 weeks	no
Halliwell and Solan	1972	35	70	2	2	1	31 hours	27 weeks	no
Jens	1970	400	?	2	2	3	?	1 school year	no
Morgan	1966	40	40	2	2	4	variable	variable	no
Ryan	1973 Phase I	50	50	2	2	2	570 hours	3 years	no
	Phase II	25	25	2	2	2	270 hours	1 1/2 years	no
Shearer	1969	40	40	1	2	3	20 hours	22 weeks	no

TABLE 1 (CONTINUED)

Authors	Date	Subjects: Number E	Subjects: Number C	Ages	Setting	Experimental Design	EHT	DOT	Follow-up
Weisz	1979	14	14	2	1	2	25 hours	2-3 weeks	no
Young	1971	27	83	2	2	1	81 hours	36 weeks	no

CODE

Subjects
Number-E = experimental
C = control
Age - 1 = preschool
2 = 6 to 11 years
3 = 11 years plus
Setting 1 = optometric practice
1 2 = school setting

Experimental Design

1 = large group designs with control for Hawthorne Effect and non-treatment groups.
2 = large group studies comparing other treatments with optometric vision training, however, no controls for improvement of an equivalent non-treatment group.
3 = large group designs without controls for Hawthorne Effect.
4 = group case history studies with control group, but no controls for the Hawthorne Effect.

EHT = estimated hours of training

DOT = duration of training

TABLE 2

RESULTS OF CONTROLLED STUDIES EMPLOYING OPTOMETRIC VISION TRAINING TECHNIQUES

Researcher	Visually Related Areas		Academic Skills									Perception and Memory Skills				Other Areas				
	FVS	H	A	IQ	L	ORS	RC	RR	RS	S	TR	AP	GA	VM	VPS	AG	EHC	GMR	SC	SP
Coleman				0	0	+	+	+		+								+		
Friedman						+		+												
Halgren				+		+	+	+												
Halgren & McKee			+			+	+			+										
Halgren et al.						+	+													
Halliwell & Solon						+	+													
Jens												+	+		+					
Morgan		0			+		+				+			0	+	0	+	.	+	+
Ryan-Phase I	+/0					0	0						+							
Ryan-Phase II	0					+	+					+	+		0					
Shearer									+											
Weisz															+					
Young						+	+	+												

A - Arithmetic
AG - decreased social aggressiveness
AP - auditory perception
EHC - eye hand coordination
FVS - functional vision skills
GA - graphomotor abilities
GMA - gross motor abilities
H - reduced headaches
IQ - intelligence
L - language
ORS - other reading skills
RC - reading comprehension
RR - reading rate
RS - readiness skills
S - spelling
SC - self concept
SP - sports participation
TR - teacher ratings
VM - visual memory digits
VPS - visual perception skills

to control groups. Beneficial effects that were indicated in two or more studies were found in the areas of reading skills, visual perceptual skills, grapho-motor skills, and spelling ability. Interestingly, only one study measured changes in functional visual skills as a result of optometric vision training.

A number of studies without the use of experimental controls have been performed. Large group studies without control groups include Rohr (1969) and Wilson, Keith, Mack, and Breslower (1975). Large group studies without control groups include Swanson (1972) and Wold, Pierce, and Keddington (1978). Single case studies without experimental controls include Swanson (1969), Wold and Challas (1969), Solan and Seiderman (1970), Spencer (1970), Seiderman (1972), and Ludlam, Twaroski, and Ludlam (1973). The above studies although lacking experimental controls suggest findings similar to those found on Table 2.

Studies demonstrating the effectiveness of remedial reading approaches in comparison with optometric vision training approaches indicate results that appear currently unclear. Young et al. (1971) and Halliwell and Solan (1972) found no significant differences between matched remedial reading and optometric vision training groups in terms of reading performance.

Phase I of the Cambrian Project (Ryan 1973) emphasized optometric vision training techniques in a school setting and found significant differences between a remedial reading group and an optometric vision training group. The optometric vision training group performed significantly higher than the remedial reading group on tasks involving visual motor integration and specific functional vision skills such as stereopsis (depth perception) and word recognition under binocular conditions. No

significant differences were found in a number of other academic and functional vision skills. Phase II of this project, in which an auditory perceptual training component was added to the optometric vision training techniques, significant gains were found in a number of areas in comparison to the remedial reading group. These gains were obtained in auditory figure ground abilities and overall achievement testing in arithmetic, word recognition, reading comprehension, and phonics skills. In that non-treatment control groups were not included, the generalizability of these findings are limited and in an empirical sense these findings do not fully substantiate whether the treatment effects were greater than no treatment at all. Questions also arise concerning the remedial reading program. The remedial reading techniques employed were not specified and it was unclear as to differences in attentional factors that may haye resulted in the two programs. For instance, was more adult attention provided for those children in the optometric vision training groups versus the remedial reading groups? If this occurred, how might the results have been influenced? Other questions arise as to the effect of auditory perception training. For instance, would auditory perceptual training be as effective without the optometric vision training?

Weisz (1979) compared the effectiveness of optometric vision training emphasizing accommodation skills with perceptual motor training in ameliorating accomodative difficulties (focusing problems). Weisz measured the improvement through a visual discrimination task in which children were asked to mark with a pencil all the "C" type shapes (Landolt Rings)

that were faced in a particular direction. Children who received accommodative training exhibited significantly less errors after training than children in the perceptual-motor groups. Since a no treatment control group was not included, the generalizability of the findings is limited and do not fully substantiate whether the accommodative treatment was superior to no treatment at all. The careful documentation of treatment procedures and the employment of a methodology in which the dependent measure was directly related to the initial diagnosis and treatment procedure suggest that this study may be a prototype and hopefully a model for future vision training studies.

The research methodology employed in the area of optometric vision training and the settings in which the research occurred, suggest that a number of gaps in the research exist that prevent a thorough understanding of the effects of optometric vision training on visual functioning and presumed academically related areas.

Even though a number of studies to evaluate the effectiveness of optometric vision training have been performed, agreement regarding the effect of optometric vision training on children with varying degrees of visual difficulties has not been forthcoming. The lack of a pragmatic and systematic approach in evaluating optometric vision training appears to be an important reason for this.

Many optometrists would agree that optometric vision training in the optometrist's office provides a more effective and powerful intervention strategy than optometric vision training performed in the schools. Within the optometric practice proper, optometric vision training can be

carried out by the optometrist or under the direct supervision of an optometrist. In addition, most optometrists have the sophisticated instrumentation necessary to perform optometric vision training, while this instrumentation is usually not available in the schools. However, as this review of past research indicates, with the exception of case studies and follow-up case studies, there has been a notable lack of research evaluating optometric vision training within the confines of the optometric practice.

Hersen and Barlow (1977) suggest that the application of group designs to applied problems often pose a number of difficulties. Hersen and Barlow cite difficulties or objections to large group research that include ethical objections, practical problems in collecting large numbers of patients, averaging of results over the group, generality of findings, and inter-subject variability.

Ethical problems such as withholding treatment from a no treatment control group and practical problems including obtaining a sufficient number of subjects, logistic problems involved with large numbers, and obtaining sufficient economic sanctions to make such research profitable would be sufficient to discourage practicing optometrists from engaging in such research. These problems however are not unique to optometric vision training alone and are apparent in the majority of research related to human behavior.

It is this author's contention that due to the methodological problems and the lack of substantive research related to in office optometric vision training, alternative research methodologies are necessary

in evaluating optometric vision training. A form of research methodology that meets the needs of evaluating optometric vision training in applied optometric settings is the single case experimental design methodology. Single case experimental design methodology is also known as process research, i.e. designs that measure what goes on during treatment instead of just the final outcome of the therapeutic effort. The immediate feedback related to the effects of the intervention could be of use to the practicing optometrist as well as the researcher. For instance, decisions could be made regarding the course of treatment if specific interventions did not appear effective with certain patients. The use of a limited number of subjects and the fact that all subjects obtain treatment would make the use of single case experimental designs superior to conventional large group experimental designs for use in applied optometric settings.

Directly replicating a given experiment by the same investigator on different subjects could be used to generalize positive findings to other subjects with similar backgrounds. If mixed results were obtained, these results could be attributed to specific differences among the subjects, thereby providing a clearer direction for further experimentation. Systematic replication, which attempts to duplicate findings from a direct replication across settings or therapists, could be performed to extend the generality of findings over a wide range of situations. Research efforts using single case experimental design replication procedures could take the place of large-scale replication studies using traditional large group experimental designs (Bergin & Struggs, 1972). Advantages

related to the use of single case experimental designs in comparison to conventional large group methodology are discussed by Hersen & Barlow (1977) and follows:

1. The effort would be decentralized, i.e. a number of small studies carried out in a number of applied settings versus one large collaborative factoral study. The overall cost of experimentation could be designed to be less and benefit a greater number of practioners and researchers.

2. Opportunities could be created for practioners to become part of the research process and share in publications and accompanying professional recognition.

3. Unique treatment procedures could be validated within applied settings while providing benefits directly to the subjects as well as future patients with similar problems.

4. Since the results of single case experimental designs are cumutative each new research effort would have some immediate "pay-off" for the practicing clinician.

One of the requirements of single case experimental designs is that the dependent measure or problem behavior is measured repeatedly over time. In that single case experimental design methodology has not yet been applied to evaluating optometric vision training, the need for valid and reliable repeated measurement techniques exists.

Summary

The non-systematic approach to the evaluation of optometric vision training paired with the often unsound methodological research procedures have led to difficulties in predicting the effects of optometric vision training approaches across settings. However, the research suggests that certain optometric vision training approaches may have beneficial effects

in a number of areas such as reading, grapho-motor skills, visual-perceptual skills and spelling ability, versus no treatment at all. Studies indicate that the overall effects of optometric vision training on reading are not significantly different than remedial reading approaches, although optometric vision training practitioners suggest that the specific effects of the two approaches may differ. However, at the present time there are no data supporting differential effects on specific reading errors. Although the majority of optometric vision training takes place in optometric offices, controlled studies evaluating the effectiveness of optometric vision training in optometric offices are lacking. Even though a major goal of optometric vision training is to change a child's visual functioning, controlled experiments evaluating the effects of optometric vision therapy on specific visual skills are limited. The current lack of controlled follow-up studies make a reliable understanding of the long term effects of optometric vision training difficult.

Purpose

There were several interrelated purposes for the present study. The purposes of this study include:

1. Measuring the effectiveness of a specific optometric vision training program in changing a variety of visually related behaviors of two children with visual problems in an optometric vision training practice.

2. Evaluating changes that might occur in relation to specific educational skills as result of the optometric vision training intervention.

3. Evaluating the effectiveness of specific assessment procedures to reliably and repeatedly measure educationally and visually related behavior change over time.

4. Observing changes that occur following termination of treatment through a five month follow-up.

CHAPTER II

EXPERIMENTAL DESIGN AND METHODOLOGY

I. SUBJECTS

Two elementary students served as subjects for this study. The students were referred for optometric vision training because of functional visual difficulties uncovered in previous optometric examinations.

The first student, Dave was a seven year old male with visual difficulties including hyperopia (farsightedness), accommodative insufficiency (focusing difficulties in terms of quality, quantity, flexibility, and accuracy) and an exophoric projection at near (outward eye stance). In addition, visual perceptual difficulties and reversals were evidenced. According to his parents, Dave's eyes were reddened and he complained that his eyes burned or itched after reading or performing desk work. He also held his book too close while reading or his face was too close to the desk surface while writing. According to his parents, he would often make errors in copying from the chalkboard to paper on his desk, he rubbed his eyes during or after short periods of visual activity, and fatigued in a visual sense easily. He was often observed blinking as if to make the chalkboard become clear. During academic tasks his parents indicated that he lost his place during reading, displayed a short attention span in reading or copying, repeatedly omitted "small" words while reading, and often omitted letters, numbers or phrases while writing. Dave is of

average to above average intelligence and lives with his parents. His parents are in the upper middle income range and Dave attends a Knox County elementary school. Dave was in the second grade and was having minor difficulties in school, although performing academically on grade level. According to his parents, Dave's school related difficulties included poor handwriting and difficulties in completing his work on a daily basis.

The second student, John, was an eight year old male with visual difficulties including hyperopia (farsightedness), accommodative insufficiency (focusing difficulties in terms of quality, quantity, flexibility, and accuracy) and an exophoric projection at near (outward eye stance). According to his parents, John's eyes were often bloodshot, he sometimes squinted, closed or covered one eye, needed his finger or a marker to keep his place during reading, and showed gross postual deviations during desk activities. The postual deviations included holding his book too closely while reading or his face too close to the desk surface. John was above average intelligence and lives with his parents and a younger sister. His parents live in a middle class neighborhood and he attends a Knoxville City School. John was in the third grade and was performing average to above average academically and socially.

II. SETTING

Optometric vision training procedures were conducted in the private optometric practice of J. C. Tumblin, O. D. The optometric vision training was performed by this author under the direct supervision of Dr. J. C. Tumblin. An undergraduate psychology student was trained as a research assistant to perform a number of repeated measure assessment procedures.

III. METHODS

Repeated measure assessment procedures designed to measure visual and academically related behavior repeatedly over the course of the study were employed. Repeated measures included those performed by a research assistant specifically trained to administer these assessment procedures and the experimenter. The research assistant was blind to experimental procedures and changes in these procedures during the course of the experiment. Assessment procedures included those procedures not directly related to vision training techniques and those assessment procedures in which the skills required were trained directly during the treatment stage. A randomized order was used in presenting the assessment procedures each session. In addition to the repeated measures, several pre-post assessment procedures were administered to provide additional information regarding the effects of optometric vision training.

Instrumentation has been classified into three categories. The first category was instruments that assessed skills which were not directly trained. These assessment procedures are often employed by optometrists in assessing visual, visual motor, and academic effects of optometric vision training. The second category was instruments which assessed skills that were directly trained. These assessment procedures were developed in order to directly assess the skills trained. The third category was instruments which assessed skills at the beginning and end of training. The pre-post assessment procedures assessed skills that were not directly trained and consisted of a psychological battery with

additional assessment in visual perceptual and memory related areas. In addition, the parents of both students were asked to fill out checklists before and after optometric vision training regarding changes in apparent visual symptoms that may have been indicative of visual problems. Table 3 lists the assessment procedures employed and indicates assessment procedures performed by the research assistant.

Standard Optometric Assessment Procedures

Binocular Saccadic Fixation. The student viewed a saccadic fixation letter chart from an instrument consisting of a stand with a lighted card holder and an attached viewer. The saccadic fixation chart consisted of 10 evenly spaced rows of 12 letters, each on 8-1/2" x 11" size white typing paper. At the beginning and end of each row were the letters "p," "d," "b," "q," "g," "f," "j," and "y" placed in a randomized fashion. The viewer was set 15 inches from the box. Initially no lenses were used. This was followed by changes in charts and the use of +3.00 lenses, -4.00 lenses, and +3.00 and -4.00 lenses. The student was required to read the chart outloud, the first and last letter in each row, starting at the top row and progressing to the bottom row. When lenses were used, the research assistant would begin with the initial lens power and then take it away or switch lens power after the child read the first four rows and then reinstate the initial lens power after the eighth row. This caused an accommodative (focus) change from +3.00 to plano (no lens power), -4.00 to plano, or +3.00 to -4.00. The student was asked to read the letters

TABLE 3

ASSESSMENT PROCEDURES EMPLOYED AND THOSE PROCEDURES PERFORMED BY RESEARCH ASSISTANT

Assessment of Standard Optometric Training Procedures	Standard Optometric Assessment Procedures	Academic and Visual Motor Skills Assessed
1. Adapted Robbin's Rock	*1. Binocular Saccadic Fixations	*1. Coding
*2. Rotations	*2. Keystone Aviator Series	*2. Paragraph Reading
3. Space Rock	*3. Keystone Visual Skills Lateral Posture	
*4. Tachistoscope	*4. Keystone Visual Skills Stereopsis	
5. Directionality	5. SILO Base 15 Prism	
6. Quoits		

*Assessment procedures performed by research assistant.

as quickly and accurately as possible. The student's performance was timed, recorded on tape and was later scored by computing the number of correct responses per second.

Keystone Aviator Series. The Keystone Aviator Series consists of a set of twelve slides that when viewed through a Telebinoculor are designed to assess stereopsis (depth perception and binocularity). Each slide has three vertical columns of randomly assigned letters and numbers. In each column one letter or number is offset 1300 to 10 seconds of arc, depending upon the card. The effect that occurs is that the offset letter or number appears to project out toward the viewer. The student was required to indicate which number or letter appeared to be closer to him or stick out at him. The 12 cards were randomly arranged before each presentation. Depending upon the number of correct answers given, a stereopsis score could be derived from 0 to 110 percent stereopsis. All twelve cards were randomly administered in each assessment session.

Keystone Lateral Posture. The two Keystone Lateral Posture cards were designed to assess lateral posture of the eyes at rest when viewed through a Telebinocular. Lateral posture was performed at a simulated near point (approximately 16 inches) and far point (twenty feet) in order to determine if overconvergence, underconvergence, or an unstable convergence posture were present. Both cards consist of an arrow and a set of numbers in sequential order. Optimum performance was when the arrow pointed to the five at near and the ten at far. Scores greater than five

at near and ten at far indicate varying degrees of underconvergence, while scores less these numbers indicate overconvergence. An unstable posture was indicated when the scores moved from number to number over time.

Keystone Stereopsis. The Keystone Stereopsis card was designed to assess stereopsis when viewed through a Telebinocular. The card consists of twelve rows of five shapes (star, box, cross, heart, and circle). In each row one of the shapes was offset a certain degree of arc. The effect that occurred was that the offset shape appeared to project out toward the viewer further than the other shapes. The degrees of arc decreased beginning from the first row to the twelfth row. The student was required to indicate which shape appeared to be closer to him or stick out at him. Each shape correctly identified was given a score of 4 percent stereopsis. Depending upon the number of correct answers given, a stereopsis score was derived from 0 to 48 percent stereopsis.

SILO Base 15 Prisms. Each student was required to view a letter chart ten feet away with four pairs of glasses. Each pair of glasses contained base 15 prisms that were yoked in either a base-up, base-down, base-right, or base-left orientation. The chart contained lines of random letters. The student was first asked if the chart appeared bigger or smaller than without the glasses. He was then asked if the chart appeared closer or farther away than without the glasses. The optics of the lenses cause an effect in which the chart will appear either smaller and closer (small - in) or larger and farther out (large - out). This is the

opposite of what is normally seen, i.e. things that are smaller are usually farther away and things that are larger are closer. SILO can only occur when the two eyes are working in a binocular fashion. Therefore SILO is a measure of binocularity and integrative visual functioning. One set of responses were obtained for each pair of glasses. The number of correct responses per session varied from one to four.

Standard Optometric Training Procedures Assessed

Adapted Robbin's Rock. A stereoscope set at sixteen inches viewed two cards in a binocular fashion (each card was seen by each eye separately, but the eyes were not allowed to work binocularly). Each card had a scene of a building with either a red or green background. On each card there are one half of the letters of the alphabet sequenced in an alternating letter arrangement. A minus 4.00 lens was placed in the eye that viewed the red card and a +3.00 lens in the card that viewed the green lens. With a pointer in each hand the student was required to point to the letters of the alphabet in sequence as quickly as possible. The number of letters correctly identified and pointed to in sixty seconds was recorded. Lenses and cards were reversed and the procedure was repeated.

Rotations. The rotator consisted of a motorized circular disk on a three foot stand. Eight numbered circular patterns are arranged in a circular fashion on the circular disk. The pattern rotated in a clockwise direction at twelve revolutions per minute. The student was asked to pursue circular pattern number eight for as long as possible without losing

the target. The number of successfully completed rotations was recorded for the right eye only, the left eye only, and both eyes together. To insure reliability in recording the number of successfully completed rotations, both the experimenter and research assistant simultaneously agreed on the student's loss of the target.

Space Rock. The Space Rock instrument is a wooden pegboard containing twenty-four rods of varying lengths, that project outward from the pegboard. The rods are labeled 1-24 and the student was required to point to the rods in sequential order using the pointers. The number of rods correctly pointed to in a sixty second period was recorded. In that the rods were removable, the positions of the rods were randomized.

Tachistoscope. The Lyons and Lyons Arrow Series which consists of a series of slides with arrow configurations differing in number and position in space was used. Each slide was projected for 1/60th of a second on a screen eight and one half feet away. The student was required to reproduce twenty arrow patterns on a form consisting of twenty boxes. Slides were randomized in order of presentation and position in space shown. The percentage of correct responses was later scored by the research assistant and recorded.

Directionality. A chart containing ten lines of ten "U's" each was used. The "U's" were placed on the chart in a randomized right, left, up, or down direction. The chart was also notated and was placed ten feet from the student. The student was asked to

identify which way the open part of the "U" pointed, starting at the first line and going left to right across each line as quickly and as accurately as possible. After a thirty second period the student was asked to stop. The number of correct responses in this period was recorded. Directionality was taught as part of the Harmon Rail routines, i.e. as the student walked the rail he would practice reading the chart.

Quoits. The quoits are a set of two vectogram 8 x 5 transparent slides. The quoit slides are pictures of rope rings, one on each slide. The slides were placed in the vectogram viewer and polaroid glasses were worn. The quoit slides are designed so that the ring of the right side can only be seen by the right lens of polaroid glasses and the left side by the left lens. Initially both slides are together. When the quoits are separated in a lateral fashion, the image can be held together only if the eyes are converged or diverged in a binocular fashion. The student was asked to try to keep the quoit in one circle as long as possible. He was asked to state when the one quoit split into two. At this point the quoits were slid slowly back together. The student was asked to get the two rings into one ring and then tell the experimenter. This process resulted for the base-in eye posture change (eyes moving out) and base-out eye posture change (eyes moving in). The quoits have measurement scales attached and the scores were recorded starting at zero at which time the eyes were at a normal posture and the quoits were together, to progressively higher numbers in each direction indicating the ability to maintain binocularity at varying degrees of convergence or divergence of the eyes. Scores indicating the recovery of binocularity were also recorded.

Academic and Visual Motor Skills Assessed

Coding. A set of twenty coding sheets were developed in a randomized manner. The symbols "p," "b," "d," "q," "g," "f," "j," and "y" were used and paired with the numbers one through eight. Three rows of 47 randomly chosen numbers were placed on a chart with blank boxes beneath each number. The student was asked to fill in the blank boxes in the chart using the paired symbol-number code at the top of the sheet. The student was asked to fill in the three rows of boxes as quickly and accurately as possible. No erasing was allowed. The time to successfully complete the task was recorded. The task was later scored by computing the number of correct responses per minute. Inter-rater reliability was .97 with a range between .89 and 1.0. Twenty-four randomly selected coding sheets were used to obtain inter-rater reliability.

Paragraph Reading. Short stories from SRA (Rasmussen and Goldberg 1969) were read by the students each session. The reading grade level was initially estimated from the Diagnostic Reading Scales (Spache 1972) given during the pre-test session. Each student's reading error rate was set at approximately the 20 percent error level. It was hypothesized that if improvements due to optometric vision training occurred, these improvements would be more readily apparent at a frustration reading level. Dave's grade level was set at 3.5 and he read stories from Blue 1C and Brown IIC of the SRA program. John's grade level was set at the 5.5 grade level and he read stories from Red 1C and Olive 2C of the SRA program. All reading sessions were recorded on cassette tape. The reading passages

were later scored in a blind fashion by a research assistant. Scoring criterion were taken from the Gilmore Oral Reading Tests Manual of Direction (Gilmore and Gilmore 1968). In addition to the total error and reading rate the following specific oral reading errors were scored; substitutions, mispronunciations, words pronounced by the examiner, disregard of punctuation, insertions, hesitations, repetitions and omissions. Inter-rater reliability was obtained for total and specific errors on ten stories chosen randomingly. Interrater reliability means and ranges follow: Total error mean .94 range .83 to 100, disregard of punctuation mean .84 range .71 to 1.00, hesitation mean .95 range .80 to .96, insertion mean .88 range .67 to .100, mispronunciation mean .91 range .73 to 1.00, omission mean .92 range .75 to 1.00, repetition mean .88 range .80 to .96.

Pre-Post Assessment Procedures

Pre-post assessment measures were also administered. These measures included the McCarthy Scales of Children's Abilities, the Motor-Free Visual Perception Test, the Jordan Left-Right Reversal Test, the Test of Auditory Analysis Skills, the Developmental Test of Visual Motor Integration (Dave only), the Bender Motor-Gestalt Test (John only), the Visual Aural Digit Span Test, and the Educator's Checklist of Observable Clues to Classroom Vision Problems.

IV. EXPERIMENTAL CONDITIONS

A single subject multiple baseline design across two students was used (Baer, Wolf, and Risley 1968; Herson and Barlow, 1976). Experimental conditions included a baseline, two stage vision training sequence, and a five month follow-up after training. The two stage training package was similar in most respects to that employed by optometric vision training practitioners throughout the country. The treatment interventions were time lagged so that neither intervention began at the same time for both students.

Throughout baseline and treatment conditions both students were seen twice weekly for approximately one and one half to two hours per session. The times of arrival during treatment were staggered so initially the first student was assessed upon arrival and the second student was assessed while the first student obtained optometric vision training. Table 4 displays the sequence of optometric vision training procedures performed. Changes that occurred within these procedures are indicated by the types of changes and the session in which the change occurred. The purpose of these procedural changes were to intensify or increase the difficulty of the training procedure. Lenses or prisms employed are also displayed on Table 4. Throughout the study, lenses and types of prisms employed were determined by Dr. Tumblin.

Baseline

The baseline phase was employed to assess the natural occurring visual functioning of the subjects. In this phase the subjects were

TABLE 4

DISPLAYS THE SEQUENCE OF OPTOMETRIC VISION TRAINING PROCEDURES PERFORMED AND CHANGES THAT OCCURRED WITHIN THESE PROCEDURES BY TYPES OF CHANGE AND THE SESSION THE CHANGE OCCURRED

Training Procedures	Monocular Stage										Biocular/Binocular Stage								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	Sessions																		
Dave																			
Harmon Rail	w/o	w/o	+1.00	+1.00	B.D.	B.D.	B.D.	B.D.	B.D.	B.D.									
Monocular Rotations	w/o	w/o	w/o	w/o	w/o	+1.00	+1.00	+1.00	+1.00	+1.50									
Bimanual Chalkboard Exercises	B.D.	B.D.	B.D.	B.D.	B.D.	B.D.	B.D.	B.D.	B.D.	B.D.									
Adapted Robbin's Rock	+3/-4	+3/-4	+3/-4	+3/-4	+3/-4	+3/-4	+3/-4	+3/-4	+3/-4	+3/-4									
Space Rock	w/o	w/o	w/o	+1.00	+1.00	+1.00	+1.00	+1.50	+1.50	+1.50									
Monocular Saccadic Fixations	+1.75	+1.75	+2.00	+2.25	+2.50	+2.50	+2.75	+3.00	+3.00	+3.00									
Tachistoscope	w/o	w/o	w/o	w/o	w/o	w/o	w/o	w/o	w/o	w/o									
Penlight	S	S	B.B.	B.B.	B.B.	B.B.	B.B.	B.B.	B.B.	B.B.									
Jump Ductions with Binocular Rotations											w/o	w/o	w/o	w/o	w/o	w/o	w/o	w/o	w/o
Quoits																w/o	w/o	w/o	w/o
Zipper Effect											w/o	w/o	w/o	w/o	w/o	w/o	w/o	w/o	w/o
Chalkboard Fixations											w/o	w/o	w/o	w/o	w/o	w/o			
Red-Red Rock											±1.00	±1.00	±1.00	±1.00	±1.00	±1.00			
Binocular Saccadic Fixations																	±2.00	±2.00	±2.00
Stereoscope Van Orden											w/o	w/o	w/o	w/o	±1.00	±1.00	±1.50	±1.50	±2.00
Cheiroscopic Drawings											w/o	w/o	w/o	w/o	w/o	w/o	w/o	w/o	w/o
Tachistoscope											w/o	w/o	w/o	w/o	w/o	w/o	w/o	w/o	w/o
Penlight											V. B.B.	V. B.B.	V. B.B.	V. B.B.	V. B.B.	V. B.B.	V. B.B.	V. B.B.	V. B.B.
John																			
Harmon Rail						w/o	w/o	+1.00	+1.00	+1.00	+1.00	+1.50	+1.50	+1.50					
Monocular Rotations						w/o	+1.00	+1.00	+1.00	+1.00	+1.00	+1.00	+1.00	+1.50					
Bimanual Chalkboard Exercises						B.D.	B.D.	B.D.	B.D.	B.D.	B.D.	B.D.	B.D.	B.D.					
Adapted Robbin's Rock						+3/-4	+3/-4	+3/-4	+3/-4	+3/-4	+3/-4	+3/-4	+3/-4	+3/-4					
Space Rock						w/o	w/o	+1.00	+1.00	+1.00	+1.00	+1.00	+1.00	+1.00					
Monocular Saccadic Fixations						+3.00	+3.00	+3.00	+3.00	+3.00	+3.00	+3.00	+3.00	+3.00					
Tachistoscope						w/o	w/o	w/o	w/o	w/o	w/o	w/o	w/o	w/o					
Penlight						S.	S.	B.B.	B.B.	B.B.	B.B.	B.B.	B.B.	B.B.					
Jump Ductions with Binocular Rotations															w/o	w/o	w/o	w/o	w/o

TABLE 4 (CONTINUED)

Training Procedures	Monocular Stage										Biocular/Binocular Stage								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	Sessions																		
Quoits																	w/o	w/o	w/o
Zipper Effect															w/o	w/o	w/o	w/o	w/o
Chalkboard Fixations															w/o	w/o			
Red-Red Rock															±1.00	±1.00			
Binocular Saccadic Fixations																	±2.00	±2.00	±2.00
Stereoscope Van Orden															w/o	w/o	w/o	w/o	w/o
Cheiroscopic Drawings															w/o	w/o	w/o	w/o	w/o
Tachistoscope															w/o	w/o	w/o	w/o	w/o
Penlight															V.	V.	V.	V.	V.
															B.B.	B.B.	B.B.	B.B.	B.B.

Key

+1.00, +1.50 etc. = lens power employed
B.D. = base down prism employed
V. = vertical prism
w/o = without lenses or prism
S. = performed while standing
B.B. = balance board used

assessed on all the repeated measures. Repeated measures employed included Adapted Robbin's Rock, Rotations, Space Rock, Tachistoscope, Directionality, Quoits, Binocular Saccadic Fixations, Keystone Aviator Series, Keystone Visual Skills Lateral Posture and Stereopsis, SILO Base 15 Prism, Coding, and Paragraph Reading. The length of each baseline session was approximately one and one half hour.

Stage I: Monocular Training

The initial training stage was called the monocular stage. The purpose of the monocular stage was to equalize the monocular status of both eyes, thereby eliminating suppression patterns and preparing the eyes to be teamed together in the second stage of training. Monocular training was performed with one eye covered. The training procedures were designed to require the training of fixational skills, pursuits, rotations, and accommodative abilities on a monocular basis. The following training procedures were employed in the monocular stage of training.

Adapted Robbin's Rock. The purpose of this technique was to increase the student's accommodative facility (focusing ability). In addition, fixational skills were taught on a biocular basis. The child was required to notice detail and develop accurate fine motor control without binocular depth cues.

Training Procedure.

1. The platform light was switched on and the apparatus was adjusted for the child.

2. The viewer was set at the proper distance.

3. The cards were placed on the platform with respect to the lens utilized.

4. With a pointer in each hand, the student was required to point to the letters of the alphabet in sequence. The student was required to perform the task with increasing speed and accuracy.

5. To vary the task, letters were pointed to by the experimenter and the student was required to say the letters.

6. The power of the lenses was progressively increased to +3.00, -4.00.

Aspects Emphasized.

1. When pointing to the letters the child was asked to follow the tip of the pointer from the viewer to the letter.

2. The child was also asked to maintain clear vision throughout.

Bimanual chalkboard exercises. With a piece of chalk in each hand the student was asked to draw various designs in a symetrical manner using each hand simultaneously. The purpose of this technique was to develop sensory awareness in relation to the student's kinesthetic and visual system and to encourage both sides of the body to work simultaneously while exhibiting adequate fine and gross motor coordination.

Training Procedure.

1. The student stood directly in front of the chalkboard with appropriate lenses or prisms.

2. The student drew an "X" on the board directly in front of and bisecting his midline at eye level.

3. With a piece of chalk in both hands the student was asked to draw various designs with both hands on opposite sides of the "X." Both hands were to draw the exact same design in exactly the same symetrical manner.

4. The student was required to keep his eyes on the "X" while drawing the designs.

5. The designs included circles, eight-like figures, a lazy eight, and letters of the alphabet.

6. The student was required to draw designs using a top to bottom, left to right approach.

7. The designs increased in complexity and the prisms and lens power increased with the proficiency shown in the drawings.

Aspects Emphasized.

1. The student was encouraged to use each hand simultaneously and symetrically.

2. The student's body was to remain stationary with good posture throughout.

Harmon Rail. The Harmon Rail is a balance beam with a divider down the middle and enough room on each side so that the student could place a foot on each side of the divider. The beam is approximately nine feet long and ten inches wide. It is raised six inches off the ground. The student was asked to walk the rail forward and backward with and

without crossing over the divider. While walking the rail the student was required to read charts such as the rotated "U" chart or the "p," "b," "d," "q" chart. The purpose of the task was to develop sensory awareness while performing gross motor/visual activities. The goals were to improve gross motor coordination and develop rapid recognition and identification of shapes just noticably different.

Training Procedure.

1. Initially the student walked the rail in order to get the "feel" of it.

2. Appropriate lenses or prisms were placed on the student.

3. The student stood at the end of the rail with both feet together, ready to walk forward or backward.

4. The student walked forward across the rail without crossing his feet over the divider.

5. The student walked backward without crossing over the divider.

6. The student walked forward while crossing each foot alternately over the divider.

7. The student walked backward while crossing each foot alternately over the divider.

8. While walking across the rail, the student was asked to read the rotated "U" and "pbdq" charts aloud.

9. After competence on this task, the student was asked to perform the above task to the beat of a metronome.

Aspects Emphasized.

1. The student was to view the chart that was placed directly in front of him at all times.

2. The student was required to hold his arms out to the side to assist in maintaining balance.

3. A slow deliberate manner in order to maximize self-feedback was required.

4. Normal walking steps were required.

Monocular Saccadic Fixations. The student was asked to look through a viewer at a letter chart. The letter charts were placed on notebook size paper and were arranged in ten evenly spaced rows of twelve letters each. At the beginning and end of each of the rows were the letters "p," "b," "d," "q," "j," "f," "g," and "y" in a randomized fashion. The viewer contained a device so that additional lenses could be rapidly administered or taken away. The maximum amount of plus lens the student could clear was placed in the viewer and one eye was covered. The student was asked to read the letters outloud, the first and last letter in each row, starting at the top row and progressing to the last row as quickly and accurately as possible. The lenses were flipped in and out of position to achieve an accommodative rock from plus to plano (no lenses). Lens power was systematically increased in both eyes to achieve maximum and equal plus acceptance. The purpose of this technique was to teach the student to make rapid and accurate monocular saccadic fixations (eye jumps) under various focusing demands.

Training Procedure.

1. The student was seated in front of the instrument and the instrument was adjusted to the student's eye level.

2. The maximum amount of plus lens the student could clear was placed in the viewer.

3. The letter chart was placed in the holder.

4. The student placed his eyes in the viewer and read the chart by saying the first and then the last letter in each row, starting at the top row and progressing to the last row. The student was asked to read the letters as quickly as he could. One eye was covered with an eye patch and then the patch was placed on the other eye and the procedure was repeated.

5. The lenses were flipped in and out of position to achieve an accommodative rock from plus to plano.

6. Lens power was systematically increased in order to achieve maximum plus acceptance.

Aspects Emphasized.

1. Good posture throughout.

2. Both eyes were to be kept open.

3. Head movement was kept at a minimum.

Monocular Rotations. The purpose was to teach the student to track the designs on the rotator using one eye at a time in a smooth and accurate manner. In addition, the student was taught to control his accommodative functions on a voluntary basis during this procedure.

Training Procedure.

1. The student was seated two feet in front of the rotator.

2. The rotator was adjusted to the eye level of the student.

3. The rotator was switched on.

4. Either the right or left eye was occluded.

5. The student was requested to follow one of the circular designs.

6. The student was then asked to follow the design with a looped pointer, if he was having difficulty following it with his eye alone.

7. The student was questioned whether the patterns showed depth, i.e. whether the pattern projected toward or away from him.

8. Using verbal cues the student was trained to project the pattern in the desired direction.

9. Plus lenses were used to intensify the task.

Aspects Emphasized.

1. The student's head should remain still while tracking the designs.

2. When using the looped pointer, the whole arm was used in tracking the design.

Penlight. The student was required to track a penlight through a number of patterns including rotations and versions at varying distances from the eyes. This task was later performed in various positions with a verbal component and vertical prisms. The purpose was to initially teach the students to track a penlight in a smooth and accurate manner.

Once the student was able to track in a smooth and accurate manner, another task was then added in which the student was required to attend to while tracking. This resulted in order to teach the student to use his vision without having to think about it.

Training Procedure.

1. The student was required to either stand, sit, or balance on a balance board to perform the task.

2. The student tracked the penlight through a number of patterns including rotations and versions at varying distances from the eyes.

3. After the student mastered this technique, a verbal component was added, i.e., repeating digits heard or telling about his day while performing the penlight task.

4. Vertical dissociation prisms were utilized so that each eye saw one penlight separately but simultaneously.

Aspects Emphasized.

1. Good posture and accurate tracking throughout.

Space Rock. The purpose was to develop accommodative flexibility on a monocular and binocular basis. In addition, fine motor skills were developed by emphasizing the accurate use of the pointers in touching the numbers.

Training Procedure.

1. While standing approximately six inches from the nearest rod of the apparatus, the student was required to point to the numbers with

his right or left hand. The student was asked to use his right hand when the number was on the right hand side of the instrument and the left hand when on the left hand side.

2. The pointer was to be held parallel to the pegboard as the student pointed to numbers 1-24 in succession. Each eye was alternately covered.

3. Progressively more powerful lenses were used.

Aspects Emphasized.

1. While keeping elbows up, the student was asked to carefully track the pointer until the tip of the pointer touched the top of the numbered rod.

2. A pencil grip type of hold was utilized.

Tachistoscope. The purpose was to increase visual memory/visualization skills. Rapid and accurate visual fixations and grapho-motor components were involved in the task.

Training Procedure.

1. The projector was turned on and the first slide was placed in the projector.

2. The student was seated toward the screen and the arrow pattern was flashed on the screen.

3. The student was required to reproduce the arrow pattern on a form consisting of twenty boxes.

4. Ten slides were viewed. After completion of all the slides, the slides were checked for accuracy. If errors were made, the pattern was recreated correctly next to the incorrect pattern.

5. The arrow designs increased in complexity.

Aspects Emphasized.

1. Good posture and correct pencil grip.

2. Attention toward the area where the projection would appear.

3. Verbal cues for the student to visualize the image were provided.

It is important to note that a number of biocular and binocular training procedures were included in this stage of training.

Stage II: Biocular/Binocular Training

The second stage of training was the biocular/binocular stage. The purpose of this stage was to train the eyes to work simultaneously but separately (on a biocular basis) and to also achieve consistent binocularity in a number of conditions involving varying visual demands. Training procedures were designed to assist the students in learning to control the biocular and binocular visual processes effectively under conditions of varying difficulty. These procedures required the development of fixational skills, pursuits, rotations, and accommodative abilities as they related to binocularity. The following training procedures were employed in the biocular/binocular stage of training.

Binocular Saccadic Fixations. The student was asked to look through ±2.00 flippers at a letter chart. The letter charts were placed on notebook size paper and were arranged in ten evenly spaced rows of twelve letters each. At the beginning and end of each of the rows were the letters "p," "b," "d," "q," "j," "f," "g," and "y" in a randomized fashion. The student was asked to read the letters outloud the first and last letter in each row, starting at the top row and progressing to the last row as quickly and accurately as possible. The flipper was flipped to achieve an accommodative rock from +2.00 to -2.00. The purpose of this technique was to teach the student to make rapid and accurate saccadic fixations.

Training Procedure.

1. The student was seated and was asked to look through ±2.00 flippers.

2. The student was asked to read a letter chart. The flipper was changed between the +2.00 position and the -2.00 position.

Aspects Emphasized.

1. Good posture throughout.
2. Both eyes were to be kept open.
3. Head movement was kept to a minimum.

Chalkboard Fixations. While standing on a balance board with a flashlight in each hand, the student was asked to read a set of letters and at the same time shine a flashlight, on each letter. The letters

("p," "b," "d," and "q's") were placed on the wall in two vertical columns in random order. The columns were spaced opposite each other six feet apart. The balance board was placed ten feet from the center point between the two columns. The student was asked to point to the right hand column letters using the left hand and the left hand column letters using the right hand.

The purpose of this technique was to develop fixational skills and cross-lateral motor abilities. When lenses were utilized, additional motor and visual discriminations were required.

Training Procedure.

1. While standing on a balance board facing the wall with the letters, the student was required to read the letters from left to right starting at the top left card. In addition the student was required to shine a flashlight on each letter, using his left hand to point at the right column of letters and his right hand to point at the left column of letters. Feedback was given in relation to the child's performance.

2. Once the task was mastered, the student was asked to perform the task with good balance. Lenses and prism were then added to intensify the task.

Aspects Emphasized.

1. Good posture, correct discriminations, and accurate flashlight shining were emphasized.

Quoit Vectograms. The purpose of this technique was to teach the student to voluntarily converge and diverge his eyes while maintaining binocularity.

Training Procedure.

1. The student was seated comfortably at a table with the center of the vecto-viewer at his eye level.

2. The student was wearing a set of polaroid glasses.

3. The student was asked to look through the polaroid lenses at the quoits. When they were properly fused, he saw one rope ring with a circle at the top and a plus inside the circle. As the slide moved slowly toward the base-out or number range, the eyes converged. As the slide moved toward the base-in or letter range, the eyes diverged. The stereoscopic effect was to be maintained and the plus remain in the small circle at the top.

4. As the slides moved through the number range, the student was asked to be aware that the rope appears to become smaller and closer, whereas in the letter range, it becomes larger and moves further away.

Aspects Emphasized.

1. Good posture throughout.

Red-Red Rock. The Red-Red Rock is a machine that contains a lighted platform that is divided in two halves. On one half was placed the large stimulus card that contained fifteen "p," "b," "d," "q" letter combinations. On the other half were holders for fifteen identical "p,"

"b," "d," "q" chips. The student wore red-green lenses with a plus lens in one eye and a minus lens in the other. One eye viewed the letters on the chips while the other eye viewed the letters on the stimulus card. The student was asked to match the chips with the letters on the large stimulus card. Half-way through the exercise the plus/minus and red-green glasses were switched. The power of the lenses were increased when the student learned to perform the task rapidly and accurately. The purpose was to provide biocular accommodative training while teaching the child to make fine discriminations in a matching task.

Training Procedure.

1. The Red-Red Rock viewer light was turned on and the large stimulus card was put in place with the red plastic over it.

2. The student wore red-green lenses with a plus lens in one eye, and a minus lens in the other. The minus lens was always placed with the red, while the plus lens was placed with the green.

3. The student was asked to arrange the fifteen stimulus chips in front of him.

4. The student was required to match the chips with the letters on the large stimulus card.

5. Halfway through the exercise both the plus/minus lenses and red-green glasses were switched.

6. The power of the lenses was increased when the student learned to perform the task rapidly and accurately.

Aspects Emphasized.

1. The student was required to maintain good posture.

2. Both eyes were to be kept open at all times.

3. The student was asked to read the letters on the chips before placing them on the viewer.

Jump Ductions with Binocular Rotations. The student was asked to converge and diverge his eyes while maintaining binocularity from the quoit vectograms to the spriangle vectogram. A prism base-in and/or a prism base-out effect was established. In addition, the student was asked to readily switch from the above convergence-divergence task to the binocular pursuit of a target on the rotator while controlling the accommodative process (focus). The purpose was for the student to learn to quickly and voluntarily converge and diverge his eyes while maintaining binocularity when viewing alternate vectogram slides. In addition, for the student to learn to readily switch to a task involving tracking a target on a rotator while controlling his focus.

Training Procedure.

1. The student was seated comfortably at a table with the center of the vecto-viewer at eye level.

2. The student wore a set of polaroid glasses.

3. Initially both vectograms were set at zero.

4. The top slide was moved slowly into either the base-in or base-out range and the bottom slide in the opposite range of the vectogram. Convergence and divergence abilities were kept in balance by not

moving the numerals more than three or four positions ahead of the letters or visa versa. When fusion with stereopsis was achieved at a reasonable level of difficulty, the student was asked to fixate in an alternating fashion from the top to the bottom vectogram maintaining fusion at all times.

5. When this was achieved the student was asked to track various designs on the rotator while projecting the designs either toward or away from him.

6. Alternation between rotations plus focus control and increased levels of convergence and divergence ability in a binocular fashion resulted.

Aspects Emphasized.

1. Good posture throughout.

Cheiroscopic Drawings. While viewing a cheiroscopic drawing through a cheiroscope, the student was required to trace the picture on the opposite side from where it was actually viewed. The cheiroscope consists of a clipboard with an attached viewer. The instrument is designed to view each visual field separate but simultaneously, i.e. the student would view the picture with his right eye and project the image to the left side of the viewer in which he would be required to draw it. If the picture were placed on the left side the reverse would occur. The purpose of this procedure was to train both eyes to perform simultaneously, thereby assisting in eliminating suppression patterns and equalizing the effectiveness of each eye for binocular training.

Training Procedure.

1. The eye graph was placed in the cheiroscope.

2. While looking through the cheiroscope the student was required to trace the picture seen on the opposite side from where it was actually viewed.

3. The students performed a series of pictures which increased in complexity.

Aspects Emphasized.

1. The student was required to keep their eyes in the viewer throughout.

2. The student was asked to view the felt tip pen and the picture at the same time.

3. Both eyes were kept open throughout.

4. The pictures were traced with short sketchy lines rather than straight lines.

Stereoscope-Van Orden. The stereoscope is a lighted platform with an attached viewer set at twelve inches. The viewer contains prisms that provide a stereoscopic effect with Van Orden slides. Each slide has four pictures, two on the top and two on the bottom. The top pair of pictures were designed to fuse together and show depth as were the bottom pair of pictures. The distances between the pairs of pictures varied in order to necessitate fusion at varying degrees of difficulty with an inward or outward eye stance. The student was asked to view either the top or

bottom pair of pictures so that they appeared as one with a stereo-effect. Lenses were later used to cause an additional accommodative component to the convergence/divergence task. The purpose of this technique was to develop binocularity skills at varying artificially induced distances.

Training Procedure.

1. The platform light was switched on and the apparatus was adjusted for the student's comfort.

2. The viewer was set at the proper distance.

3. The first card was placed in the center of the platform.

4. The student was asked to view either the top or bottom pair of pictures so that they appeared as one with a stereo-effect. Each card was so positioned until the student had learned to fuse each with a good stereo-effect.

5. After the student had learned to fuse all the cards, the same procedure was repeated with $\pm$1.50 and $\pm$2.00 flippers.

Aspects Emphasized.

1. Good posture throughout.

2. The use of verbal cues to train the eyes to work in a binocular fashion at various in or out positions.

Zipper Effect. The Keystone Basic Binocular Test Number 12 is comprised of pairs of numerals that are arranged from "0" to "20" in a vertical sequential order. The pair of "0" numerals are placed at the top,

the left "0" green and the right "0" red. The "0's" are very close together. The "20" numerals are at the bottom with the left again green and the right red. The "20" numerals are approximately four inches apart. As the numerals increase, the distance between them also increase to form an inverted "V." With the aide of red-green glasses and by simultaneously converging both eyes together in a binocular fashion, the student was asked to fuse the pairs of numbers into one set of numbers. The purpose of this activity was to teach the student to voluntarily converge his eyes in order to fuse the pairs of numbers together.

Training Procedure.

1. The student was seated directly in front of the stand.
2. Red-green glasses were placed on the student.
3. The student was asked to make each pair of numbers into one.
4. The student was asked to systematically increase from one to twenty the pairs of numbers he could fuse.
5. After achieving fusion of all twenty numbers, the student was asked to hold fusion while tracking the card.

Aspects Emphasized.

1. Good posture while performing the task.
2. The student was required to keep both eyes open throughout.

Follow-up

A five month follow-up was performed with both students. Follow-up assessment included the same assessment procedures employed in baseline

and training conditions. Follow-up assessment occurred one time per month and lasted one and one-half hours for each student.

CHAPTER III

RESULTS

Figures 1 and 2 and Table 5 provide summary statistics including the number of data points, means, and ranges for each experimental condition. The results are categorized under the headings, "Assessment of Standard Optometric Training Procedures," "Standard Optometric Assessment Procedures," and "Academic and Visual Motor Skills Assessed."

Assessment of Standard Optometric Training Procedures

The results of the following assessment procedures can be found in Figures 3-9 and Table 5.

Adapted Robbin's Rock -4.00 left eye and +3.00 right eye (Figure 5). After an initially increasing then stable baseline, Dave increased above baseline levels in performance after the third data point in monocular training. Continued and gradual increases continued throughout treatment with a stabilization in performance after cessation of treatment in biocular/binocular training and a decrease in performance, however above baseline levels during follow-up.

John also exhibited an initially increasing baseline that then stabilized. A sharp increase in performance occurred with the initiation of treatment with continued gains into monocular training and stabilization of performance in biocular/binocular training. Follow-up showed a decrease of performance although still above baseline. In both cases,

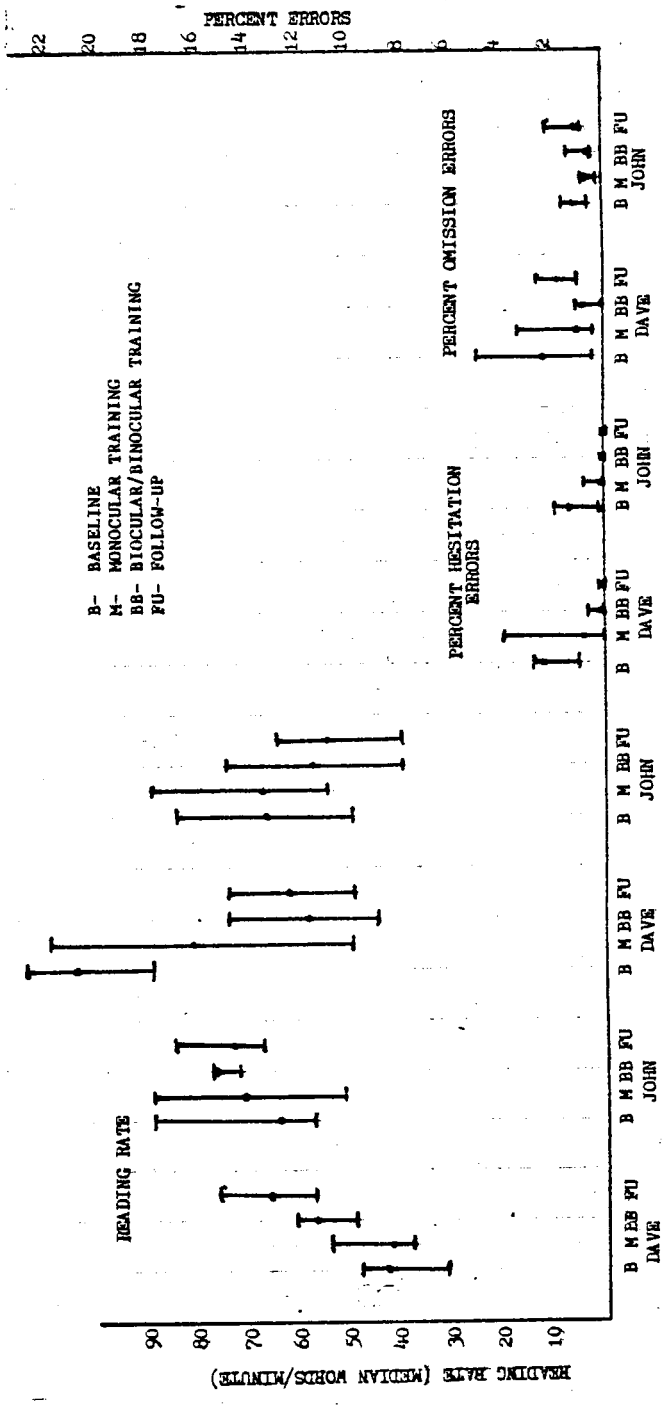


Figure 1. Reading rate and error percentage of total errors, hesitation errors, and omission errors in each of the experimental conditions of the paragraph reading.

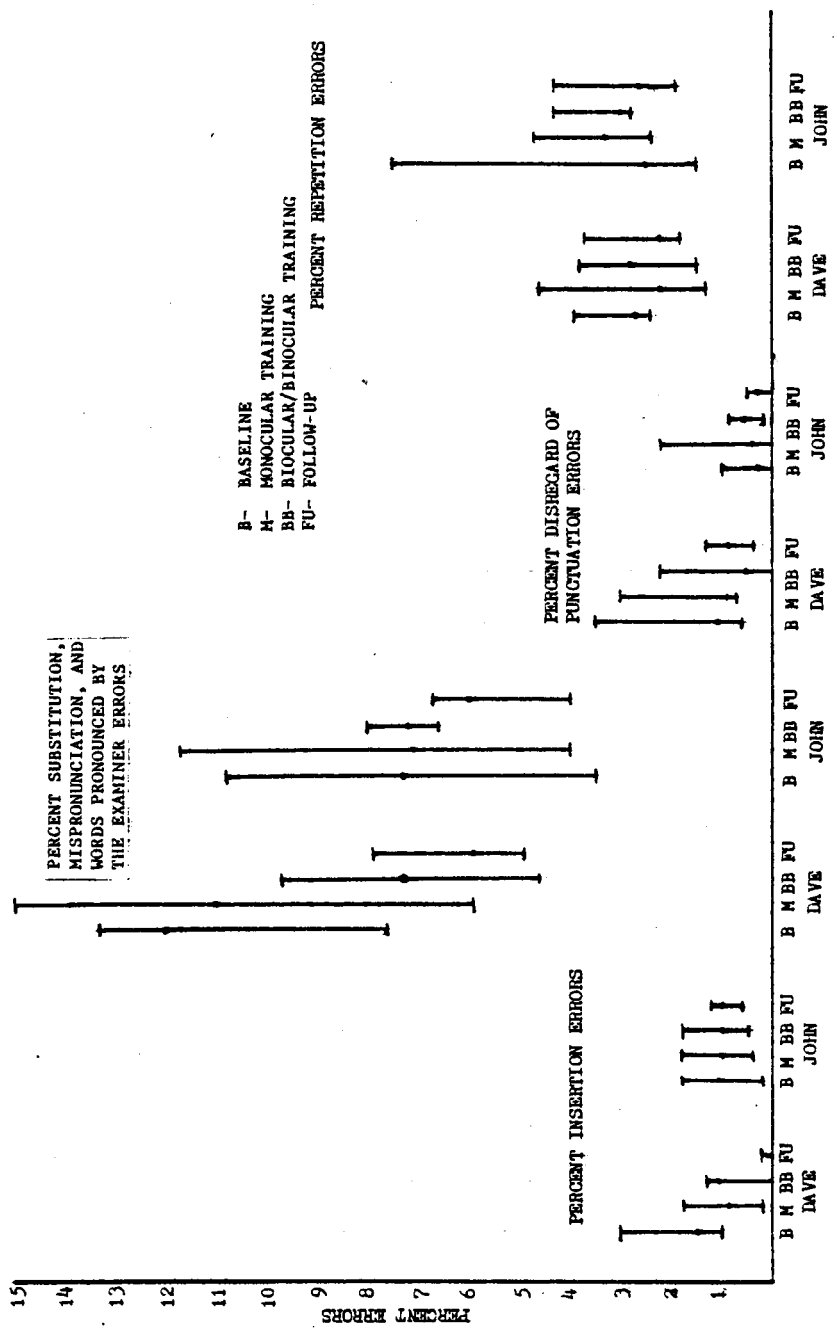


Figure 2. Percent insertion errors, percent substitution, mispronunciation, and words pronounced by the examiner errors, percent disregard of punctuation errors, and percent repetition errors in each of the experimental conditions of the paragraph reading.

TABLE 5

DISPLAYS THE MEANS, RANGES, AND NUMBER OF SESSIONS OF EACH OF THE DEPENDENT MEASURES EMPLOYED IN RELATION TO EXPERIMENTAL CONDITION (PARAGRAPH READING NOT INCLUDED)

		Dave			John		
	Experimental Conditions	Number of Sessions	Mean	Range	Number of Sessions	Mean	Range
Adapted Robbin's Rock -4.0/+3.0	Baseline	5	9.2	7 to 12	10	13.6	4 to 18
	Monocular Train.	10	13.9	10 to 18	9	31.9	23 to 42
	Biocular/Binoc. T.	8	19.4	16 to 22	4	42.8	36 to 52
	Follow-up	5	16.4	15 to 18	5	31.8	24 to 40
Adapted Robbin's Rock +3.0/-4.0	Baseline	5	8.8	6 to 10	10	15.1	8 to 23
	Monocular Train	10	14.8	12 to 22	9	32.7	19 to 42
	Biocular/Binoc. T.	8	18.6	16 to 21	4	45.0	41 to 48
	Follow-up	5	18.0	16 to 21	5	28.6	24 to 38
Rotations Right Eye	Baseline	5	6.6	3 to 11	10	1.7	0 to 4
	Monocular Train	10	34.0	4 to 61	9	53.8	27 to 100
	Biocular/Binoc. T.	8	42.8	12 to 100	4	45.8	18 to 100
	Follow-up	5	46.4	18 to 83	5	59.6	23 to 100
Rotations Left Eye	Baseline	5	5.2	3 to 11	10	5.2	0 to 8
	Monocular Train.	10	28.0	8 to 43	9	37.5	6 to 64
	Biocular/Binoc. T.	8	30.5	11 to 42	4	46.8	21 to 100
	Follow-up	5	18.0	6 to 32	5	89.4	47 to 100
Rotations Both Eyes	Baseline	15	16.4	6 to 63	19	9.0	0 to 28
	Monocular Train.	-	-	-	-	-	-
	Biocular/Binoc. T.	8	20.9	6 to 46	4	79.5	18 to 100
	Follow-up	5	39.8	17 to 63	5	56.8	19 to 100
Space Rock	Baseline	5	4.6	4 to 5	10	5.6	5 to 7
	Monocular Train.	10	8.1	6 to 10	9	16.0	10 to 27
	Biocular/Binoc. T.	8	9.9	9 to 12	4	23.3	17 to 28
	Follow-up	5	10.2	9 to 12	5	19.0	15 to 25

TABLE 5 (CONTINUED)

	Experimental Conditions	Dave			John		
		Number of Sessions	Mean	Range	Number of Sessions	Mean	Range
Tachisto-Scope	Baseline	5	15.0	10 to 20	11	31.8	20 to 45
	Monocular Train	18	37.1	15 to 65	12	85.0	65 to 100
	Biocular/Bino. T.	-	-	-	-	-	-
	Follow-up	5	74.0	40 to 70	5	71.0	60 to 85
Direction-ality Chart Per-formance	Baseline	7	14.0	11 to 20	13	25.2	20 to 32
	Monocular Train.	8	25.8	15 to 32	6	35.7	30 to 41
	Biocular/Bino. T.	8	26.1	23 to 30	4	38.8	37 to 41
	Follow-up	5	26.0	23 to 29	5	36.8	33 to 42
Quoits Base in	Baseline	18	11.8	8 to 14	18	4.7	3 to 11
	Mono & Bio/Bin. T.	-	-	-	-	-	-
	Direct Training	4	16.3	6 to 27	4	14.0	7 to 17
	Follow-up	5	13.0	11 to 19	5	16.0	13 to 19
Quoits Base in Recovery	Baseline	18	6.3	5 to 10	18	1.1	0 to 5
	Mono & Bio/Bin. T.	-	-	-	-	-	-
	Direct Training	4	12.3	3 to 23	4	7.5	1 to 10
	Follow-up	5	6.8	4 to 8	5	10.2	7 to 12
Quoits Base Out	Baseline	14	16.3	12 to 31	18	6.5	3 to 27
	Monocular Training	-	-	-	-	-	-
	Biocular/Bino. T.	8	29.8	21 to 33	4	33.0	33.0
	Follow-up	5	31.8	27 to 33	5	33.0	33.0
Quoits Base Out Recovery	Baseline	14	6.6	3 to 10	18	1.6	0 to 21
	Monocular Train.	-	-	-	-	-	-
	Biocular/Bino. T.	8	21.4	8 to 33	4	11.0	8 to 14
	Follow-up	5	25.5	21 to 31	5	17.6	17 to 19
Binocular Saccadic Fixations Without Lenses	Baseline	5	.64	.45 to .78	10	1.21	.8 to 1.5
	Monocular Train.	10	.62	.48 to .75	9	1.57	1.0 to 1.8
	Biocular/Bino. T.	8	1.05	.95 to 1.1	4	1.66	1.5 to 1.8
	Follow-up	5	.93	.6 to 1.2	5	1.62	1.3 to 1.8

TABLE 5 (CONTINUED)

	Experimental Conditions	Dave			John		
		Number of Sessions	Mean	Range	Number of Sessions	Mean	Range
Binocular Saccadic Fixations +3.00 Lenses	Baseline	5	.15	.04 to .3	10	.55	.2 to .85
	Monocular Train	10	.15	.09 to .2	9	.82	.5 to 1.1
	Biocular/Bino. T.	8	.21	.11 to .3	4	1.01	.5 to 1.4
	Follow-up	5	.36	.25 to .5	5	.70	.4 to 1.0
Binocular Saccadic Fixations +4.00 Lenses	Baseline	5	.31	.09 to .4	10	.92	.4 to 1.1
	Monocular Train.	10	.44	.3 to .6	9	1.12	.8 to 1.4
	Biocular/Bino. T.	8	.53	.5 to .7	4	.98	.25 to 1.4
	Follow-up	5	.75	.45 to 1.6	5	1.25	.6 to 1.6
Binocular Saccadic Fixations -4.0 & +3.0 Lenses	Baseline	4	.18	.16 to .2	9	.60	.1 to 1.04
	Monocular Train.	10	.30	.2 to .4	9	1.11	.74 to 1.2
	Biocular/Bino. T.	8	.41	.2 to .7	4	.96	.65 to 1.2
	Follow-up	5	.61	.5 to .76	5	1.12	.8 to 1.6
Keystone Aviator Series	Baseline	5	10.8	8.9 to 17	10	35.7	30 to 57
	Monocular Train.	9	16.5	9 to 17	9	51.5	37 to 63
	Biocular/Bino. T.	8	20.0	10 to 37	4	54.2	43 to 67
	Follow-up	5	24.7	13 to 37	5	54.0	47 to 57
Keystone Lateral Posture Near	Baseline	5	6.5	6 to 7	10	5.85	5 to 7
	Monocular Train.	10	6.0	5 to 7	9	5.44	5 to 6
	Biocular/Bino. T.	8	5.8	5 to 6.5	4	5.5	5 to 5.5
	Follow-up	5	5.4	5 to 6	5	5.1	5 to 5.5
Keystone Lateral Posture Far	Baseline	5	10.5	10 to 11.5	10	9.8	9 to 10.5
	Monocular Train.	10	9.4	8 to 10	9	9.9	9 to 10.5
	Biocular/Bino. T.	8	9.1	8 to 10	4	10.0	10
	Follow-up	5	9.3	9 to 10	5	10.1	10 to 105.

TABLE 5 (CONTINUED)

	Experimental Conditions	Dave			John		
		Number of Sessions	Mean	Range	Number of Sessions	Mean	Range
Keystone Visual Skills Stereopsis	Baseline	5	21.6	16 to 24	10	39.7	36 to 48
	Monocular Train	10	30.0	8 to 44	9	47.6	44 to 48
	Biocular/Bino. T.	8	33.0	28 to 40	4	48.0	48.0
	Follow-up	5	29.6	24 to 36	5	48.0	48.0
Silo Base 15 Prism	Baseline	5	.20	0 to .5	10	.15	0 to .5
	Monocular Train.	10	.23	0 to .5	9	.14	0 to .75
	Biocular/Bino. T.	8	.03	0 to .25	4	0	0
	Follow-up	5	.15	0 to .15	5	.10	0 to .25
Coding Task	Baseline	5	6.4	5.9 to 6.9	10	16.4	12 to 20.8
	Monocular Train.	10	9.2	7.4 to 12	9	23.6	21 to 26.6
	Biocular/Bino. T.	8	13.5	10 to 19.2	4	30.8	25 to 35
	Follow-up	5	13.4	11.7 to 16	5	30.1	26 to 35

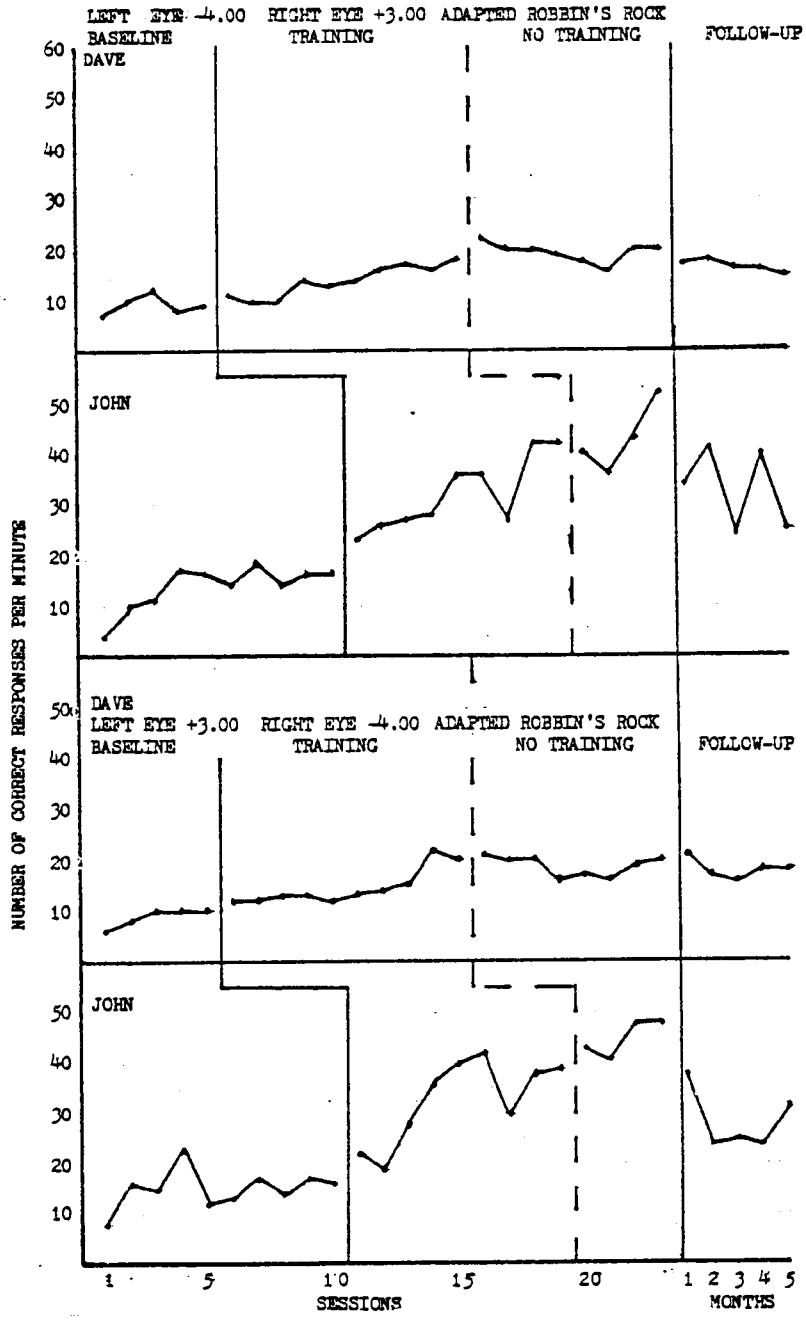


Figure 3. Number of correct responses per minute exhibited by the students in each of the experimental conditions on the Adapted Robbin's Rock.

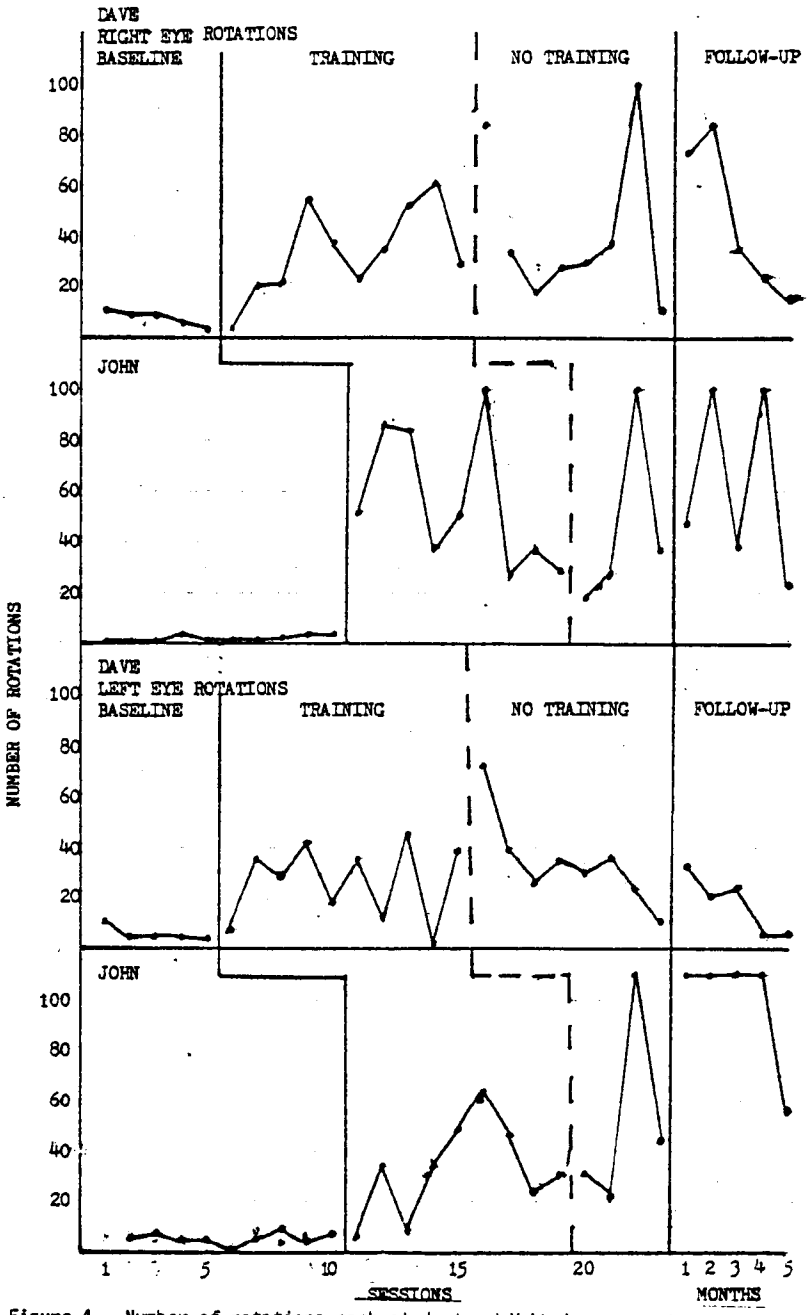


Figure 4. Number of rotations each student exhibited per session for each of the experimental conditions with either the right or left eye.

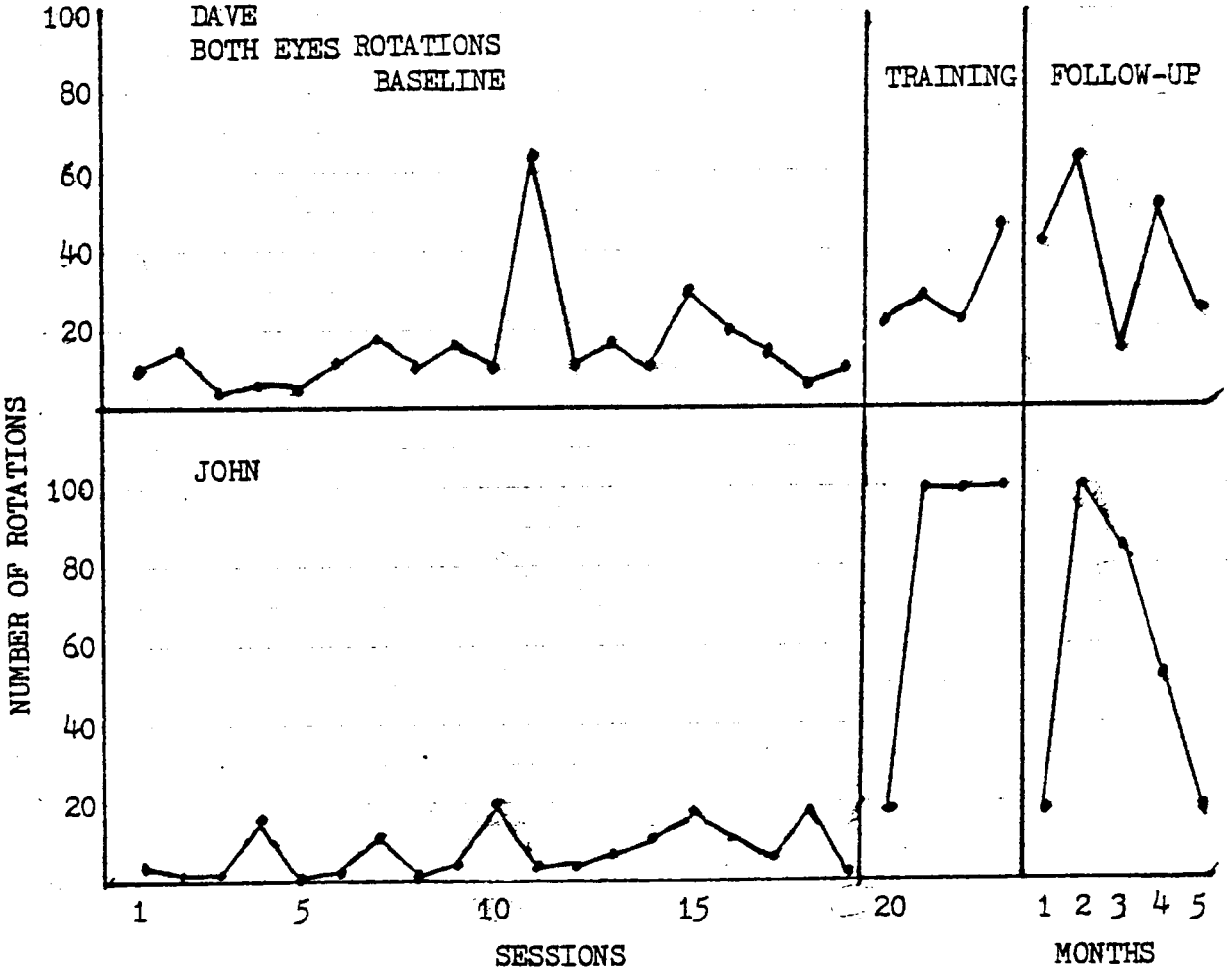


Figure 5. Number of rotations each student exhibited per session for each of the experimental conditions with both eyes.

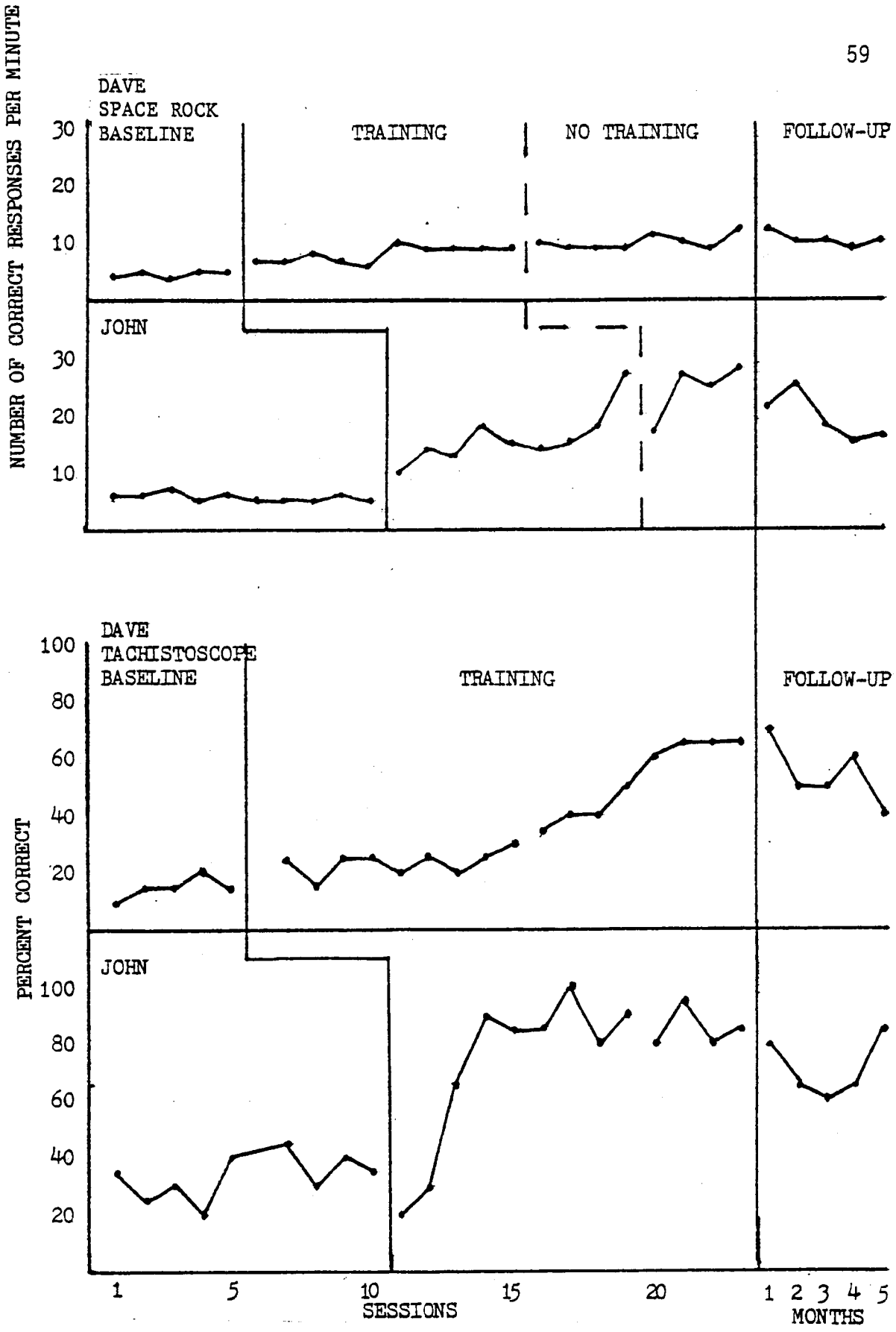


Figure 6. Number of correct responses per minute exhibited by the students in each of the experimental conditions on the Space Rock and the percent correct exhibited by the students on the Tachistoscope assessment procedure.

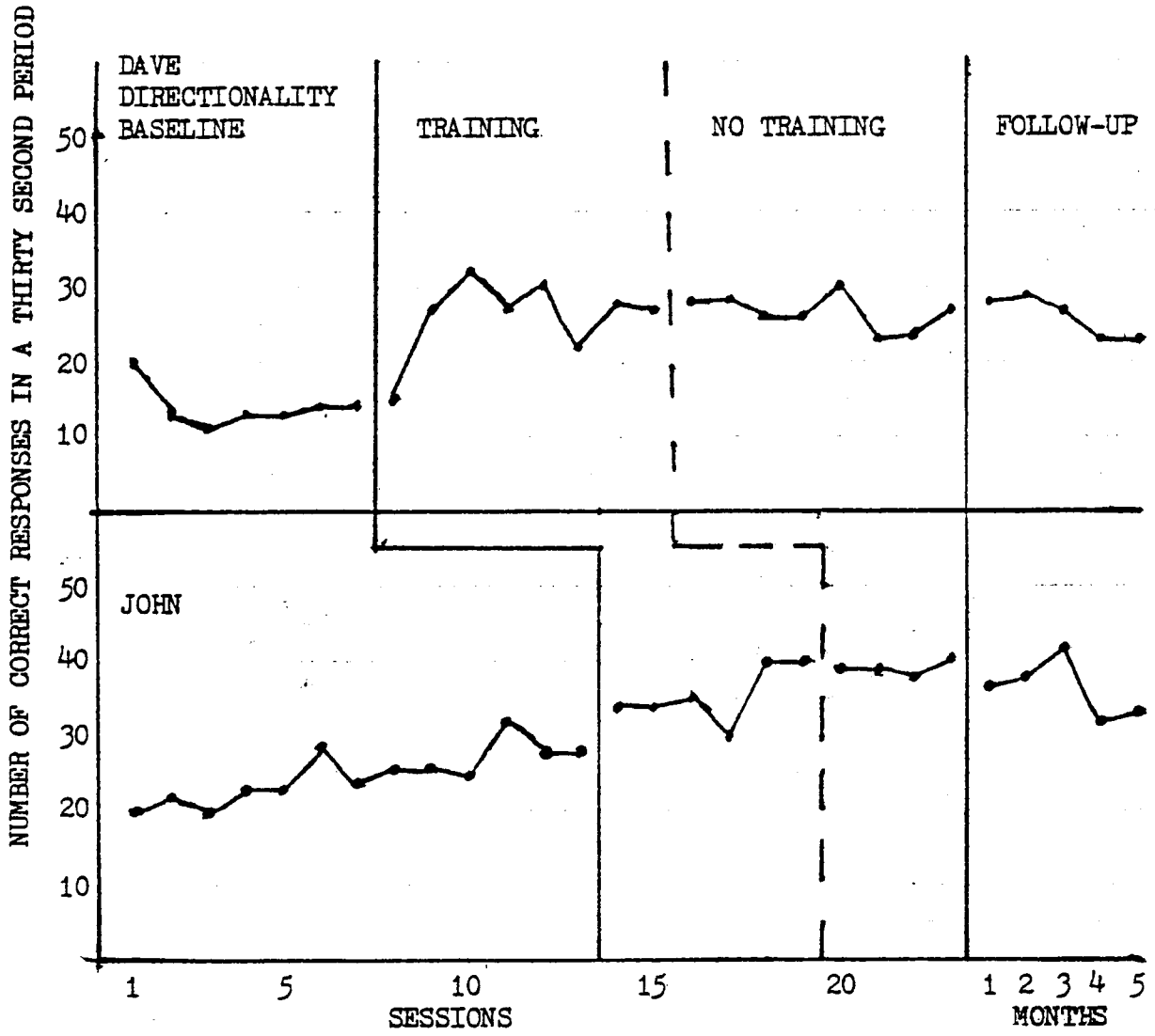


Figure 7. Number of correct responses in a thirty second period each student exhibited while performing the Directionality assessment procedure with regard to experimental condition.

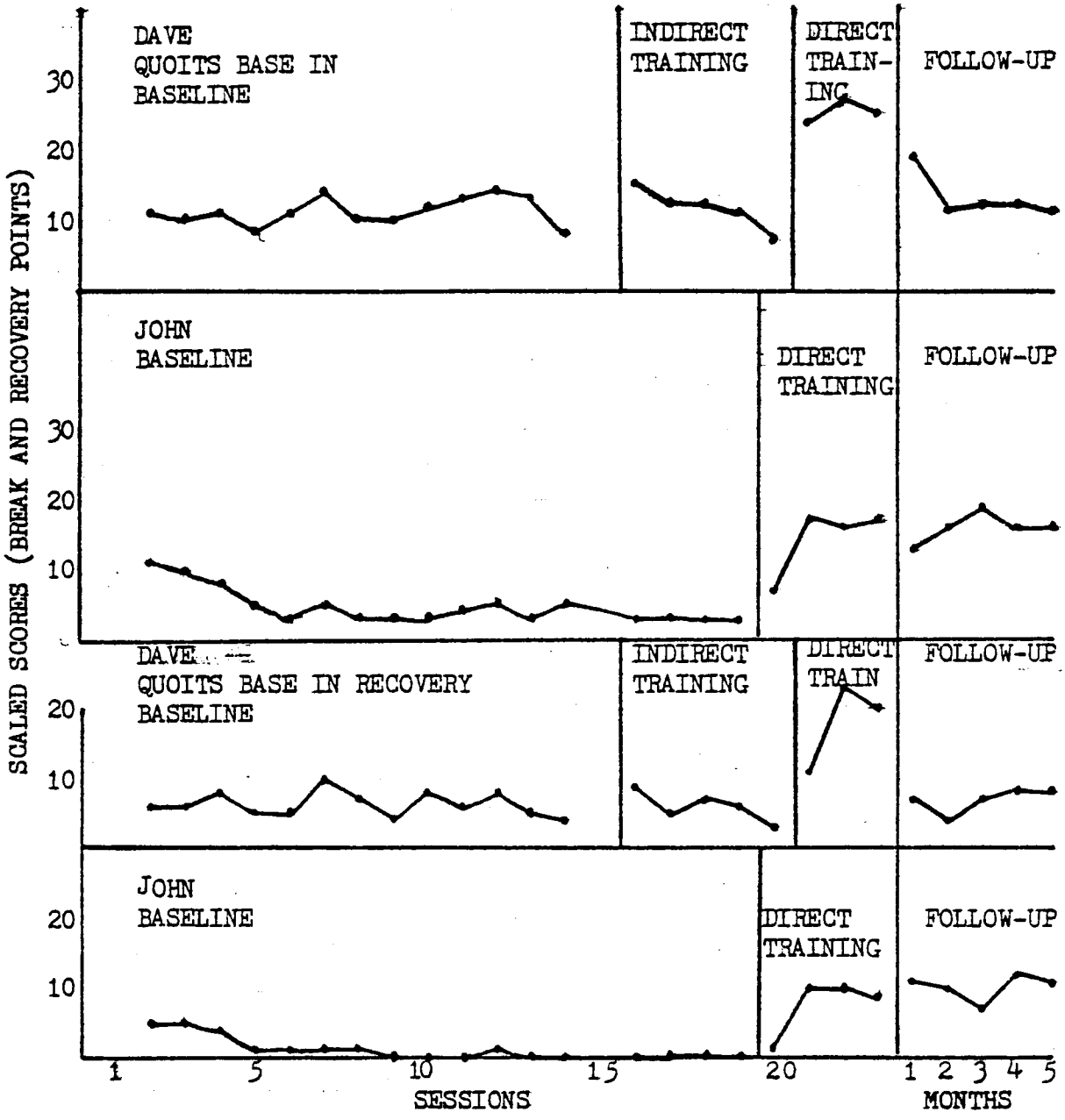


Figure 8. Break and recovery points each student exhibited while performing the Quoits Base In and Quoits Base In Recovery assessment procedure with regard to experimental condition.

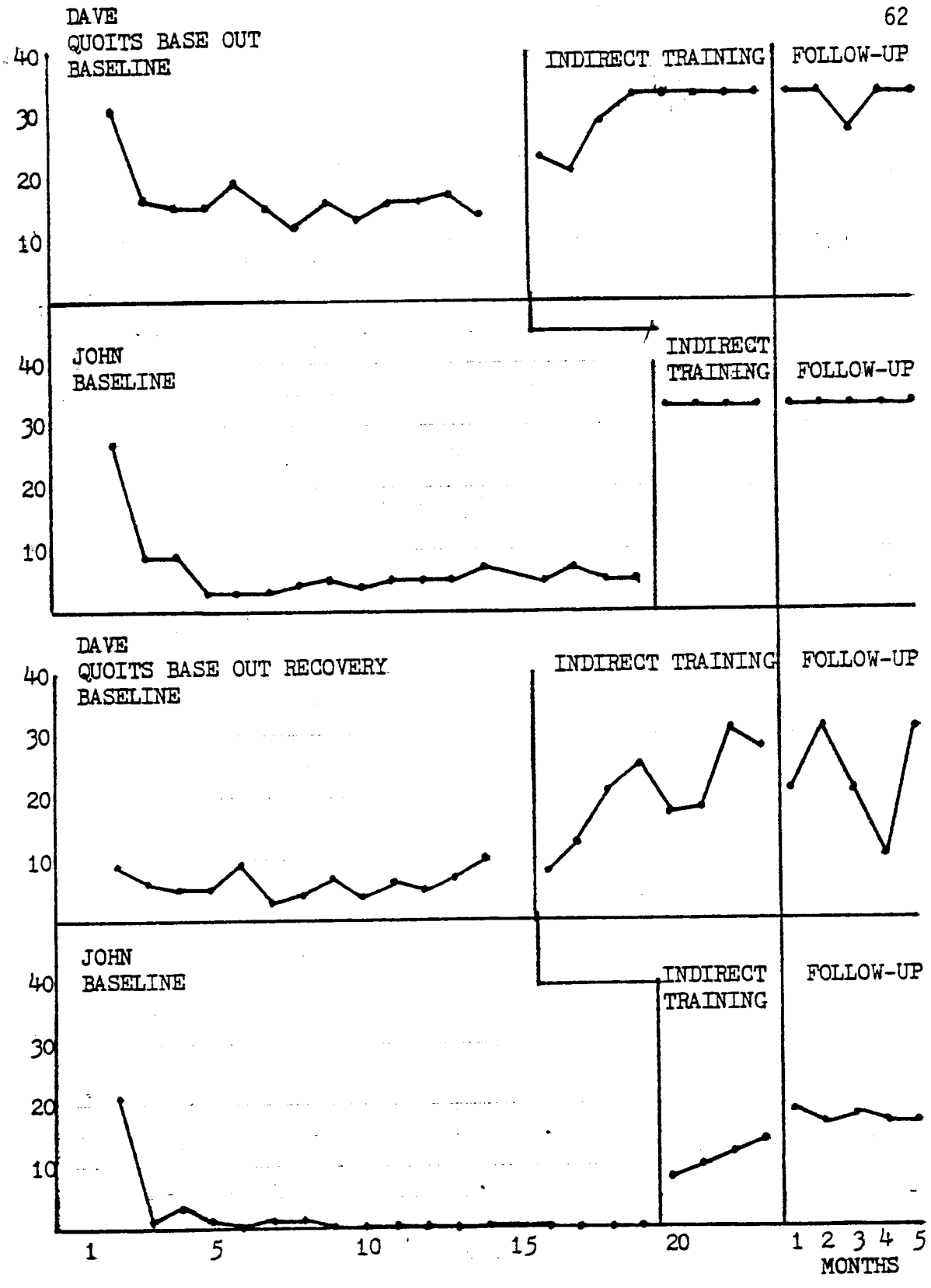


Figure 9. Break and recovery points each student exhibited while performing the Quoits Base Out and Quoits Base Out Recovery assessment procedure with regard to experimental condition.

the introduction of direct training of this skill resulted in a considerable increase in performance above baseline levels. Dave's changes were obtained without corresponding changes in John's baseline.

Adaptive Robbin's Rock Performance +3.00 left eye and -4.00 right eye (Figure 6, page 59). After an initially increasing then stabilized baseline, Dave's performance increased above baseline levels during treatment. Continued and gradual increases in performance occurred during direct training. Stabilization and then a decrease in performance occurred in biocular/binocular training and follow-up, however, performance in these conditions were above baseline levels.

John exhibited a fairly stable baseline with a sharp increase in performance immediately after the start of treatment. Gains in performance continued in monocular training with a stabilization of performance in biocular/binocular training. A decrease in performance occurred during follow-up, however, performance was still above baseline levels. In both cases, the introduction of direct training of this skill resulted in increases in performance over baseline levels. Dave's changes were obtained without corresponding changes in John's baseline.

Rotations--Right Eye (Figure 3, page 56). After a stable baseline, Dave showed a marked improvement after the initial data point in the direct training phase. Performance continued to improve until biocular/binocular training where treatment was withdrawn. Biocular/binocular training performance was variable but above baseline conditions. Follow-up

performance was initially above baseline and declined abruptly to a slightly above baseline level.

John exhibited a stable baseline and then immediate and dramatic treatment effects. These effects continued during the withdrawal of treatment in biocular/binocular treatment and in follow-up conditions.

For both boys improvements resulted during the direct training of this skill. Dave's changes were obtained without corresponding changes in John's baseline.

Rotations--Left Eye (Figure 3, page 56). Both Dave and John exhibited stable baselines and immediate and dramatic changes in performance with the onset of direct training procedures. During biocular/binocular training (withdrawal of treatment), Dave initially performed at above monocular training levels. However, performance in the latter half of biocular/binocular training and follow-up decreased from treatment levels to baseline levels in the last two points of follow-up. John's performance continued at or above baseline levels during biocular/binocular training and follow-up. Dave's performance changes were obtained without corresponding changes in John's baseline.

Rotations--Both Eyes (Figure 4, page 57). Dave exhibited a fairly stable baseline with slow and gradual improvements above the baseline condition occurring midway through the biocular/binocular treatment direct training condition. Results in follow-up were variable, with performance above baseline levels.

After a stable baseline, John showed an immediate performance increase in the biocular/binocular treatment direct training condition. These gains were initially maintained in the follow-up condition, however, a decrease in performance occurred during the last two data points to slightly above baseline levels.

Space Rock (Figure 6, page 59). Dave exhibited a stable baseline followed by an increase in performance during direct intervention. Performance continued to rise during direct training and stabilized during the biocular/binocular no treatment condition and follow-up period. After a stable baseline, John's performance increased dramatically after direct training. Performance continued to improve during direct training and stabilized during the biocular/binocular no treatment condition and follow-up. Increases in Dave's performance during treatment were not evidenced in John's baseline performance.

Tachistoscope (Figure 6, page 59). A gradually increasing baseline was followed by continued increases in performance during monocular training and biocular/binocular training by Dave. Although performance declined during follow-up, Dave's performance was still above baseline levels.

John exhibited a fairly stable baseline followed by a dramatic increase in performance after the second data point in monocular training. Biocular/binocular training performance continued at the high level obtained in monocular training. After an initial decrease in performance during follow-up, John's performance gradually increased to treatment

levels during the final points of follow-up. Even though immediate changes in performance resulted during treatment for John, Dave exhibited delayed and gradual changes in performance.

Directionality Chart Performance (Figure 7, page 60). With the exception of the first data point, Dave exhibited a fairly stable baseline. With the advent of treatment, a sharp increase in performance occurred after the first data point. With the withdrawal of treatment in biocular/binocular treatment and follow-up, a stable performance above baseline continued to be exhibited.

John exhibited a slightly increasing baseline with an increase in performance during treatment. With the withdrawal of treatment in biocular/binocular treatment and follow-up, a stable above baseline performance continued with a slight decrease in the final two points of follow-up.

For both Dave and John, the introduction of direct training of this skill resulted in an increase in performance over baseline levels. Dave's changes were obtained without corresponding changes in John's baseline.

Quoits Base In (Figure 8, page 61). Dave exhibited a stable baseline and no changes from baseline during monocular training or biocular/binocular training. During direct training, changes above baseline occurred immediately. A decrease in performance to baseline levels occurred during follow-up.

John exhibited an initially descending then stabilized baseline followed by increases in performance above follow-up levels during direct

training and Phase II treatment. Gains obtained in treatment continued throughout follow-up.

For both boys treatment gains resulted during direct training of the Quoits.

Quoits Base In Recovery (Figure 8, page 61). Dave exhibited a stable baseline and no changes from baseline during monocular training or biocular/binocular training. An immediate change in performance occurred during direct training procedures. These gains diminished to baseline levels during follow-up.

Except for the initial three data points, John's baseline performance was stable. An immediate increase in performance occurred during the direct training biocular/binocular training condition. This increase in performance was maintained during follow-up. For Dave and John treatment gains were obtained during direct training procedures.

Quoits Base Out (Figure 9, page 62). Except for the initial data point, Dave's performance during baseline was stable. However, during biocular/binocular training, Dave's performance increased with a stabilization of performance during biocular/binocular training and follow-up.

John's performance was also stable except for the initial data points. A dramatic increase in performance occurred during direct training procedures and continued into follow-up.

Increases in performance were exhibited by both boys during treatment conditions. Improvement in performance occurred by Dave during

biocular/binocular training procedures while improvements for John occurred during a combined biocular/binocular training and direct training procedures. Changes in Dave's performance during treatment occurred without corresponding changes in John's baseline.

Quoits Base Out Recovery (Figure 9, page 62). Dave exhibited a stable baseline with improvements in biocular/binocular training after the first data point. Continued improvement occurred through direct training procedures, with a variable performance at above baseline levels during follow-up. Except for the initial data point, John exhibited a very stable baseline. During the biocular/binocular training and direct training treatment stages a marked improvement resulted with continued improvements and then stabilization in the follow-up condition.

For both boys improvements occurred during the biocular/binocular treatment and/or direct training treatment conditions. Dave's changes were obtained without corresponding changes in John's baseline.

Standard Optometric Assessment Procedures

The results of the following assessment procedures can be found in Figures 9-17, page 62 and Table 5, page 52.

Binocular Sacaddic Fixations Without Lenses (Figure 10). Dave exhibited what appeared to be no change between a stable baseline and monocular training. However, during biocular/binocular training gradual increases in performance resulted that were above baseline performance. Follow-up performance fluctuated at or above the original baseline level.

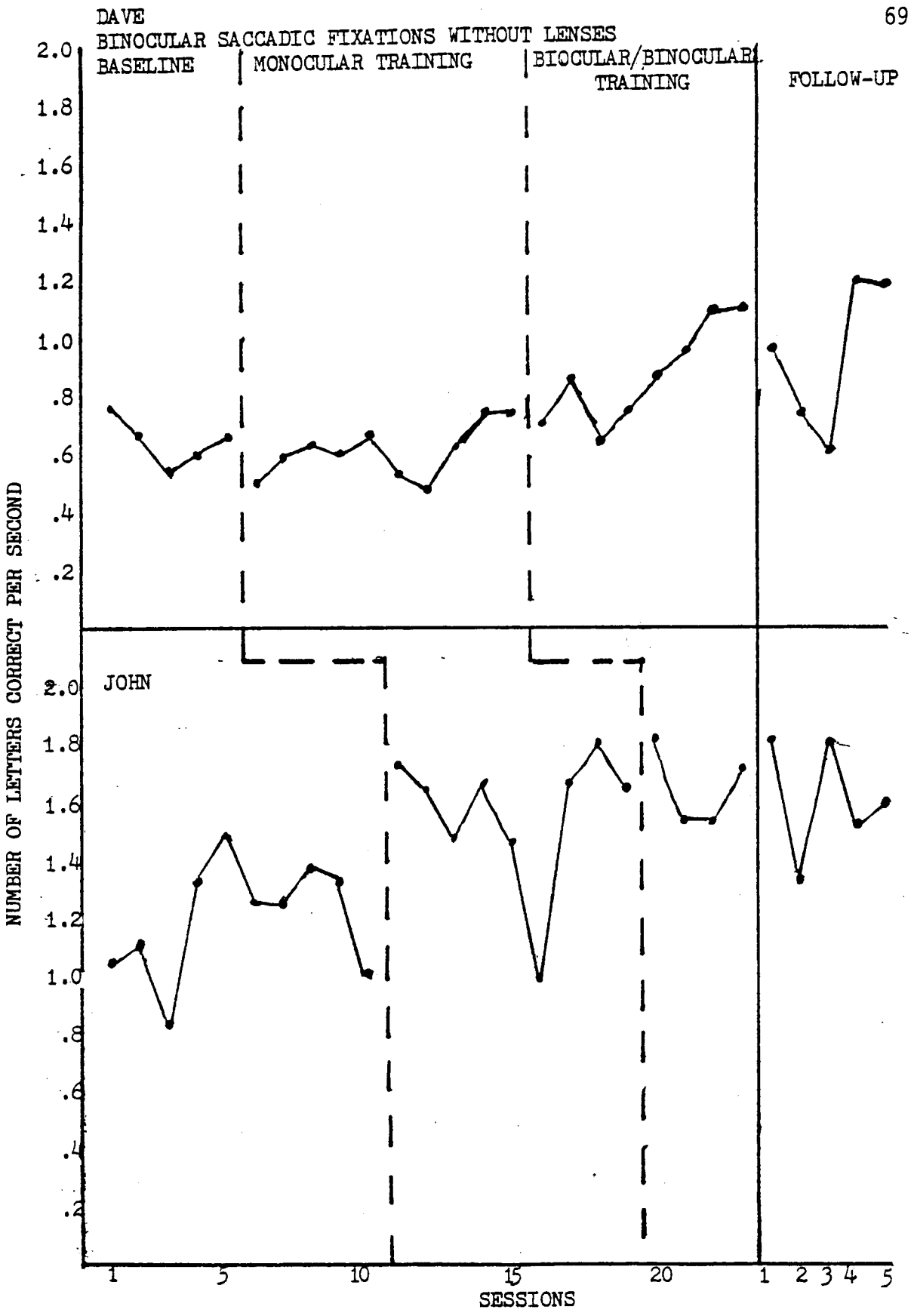


Figure 10. Number of letters correct per second exhibited by each student on the Binocular Saccadic Fixation assessment procedure while wearing no lenses.

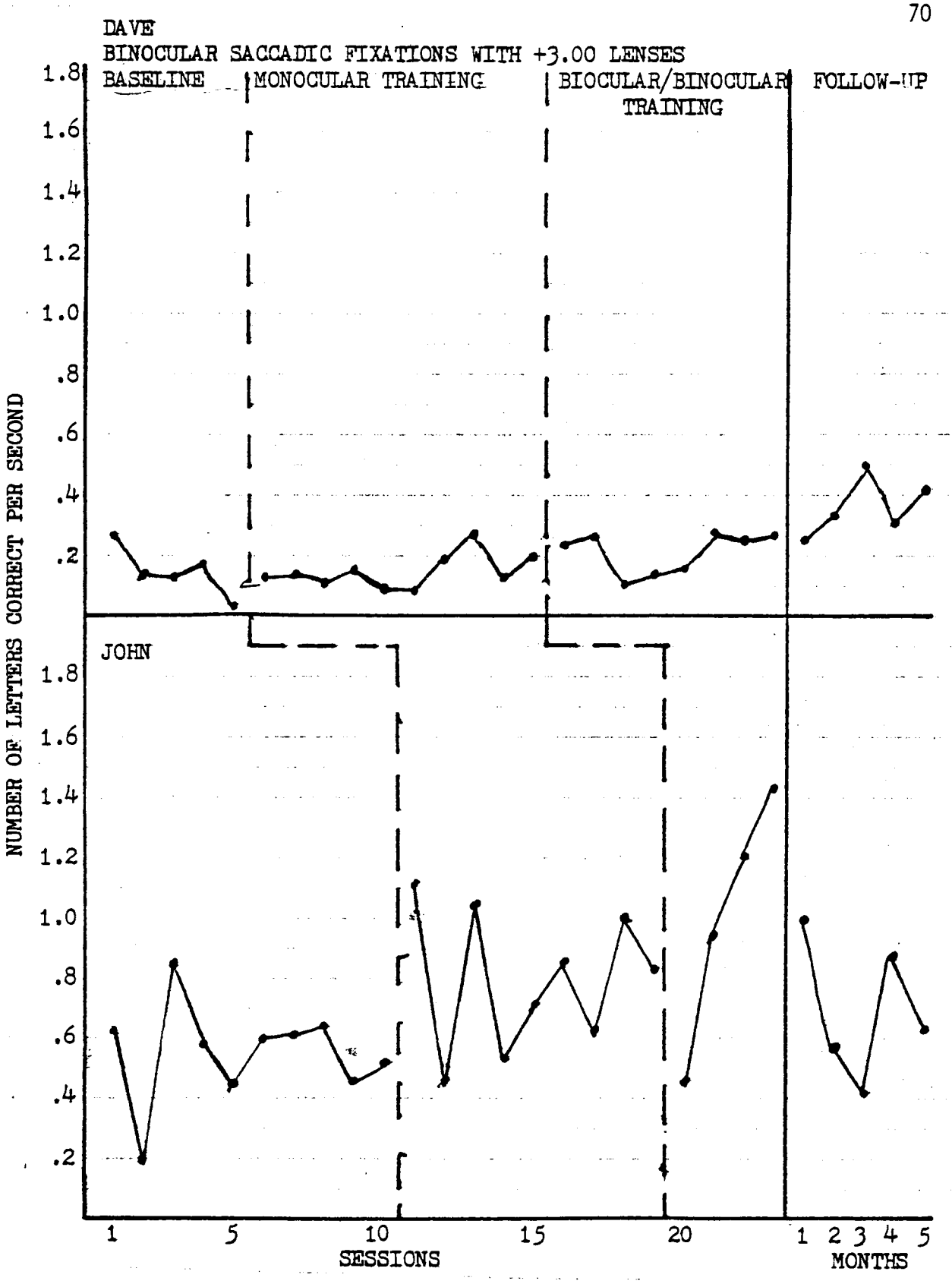


Figure 11. Number of letters correct per second exhibited by each student on the Binocular Saccadic Fixation assessment procedure while wearing +3.00 lenses.

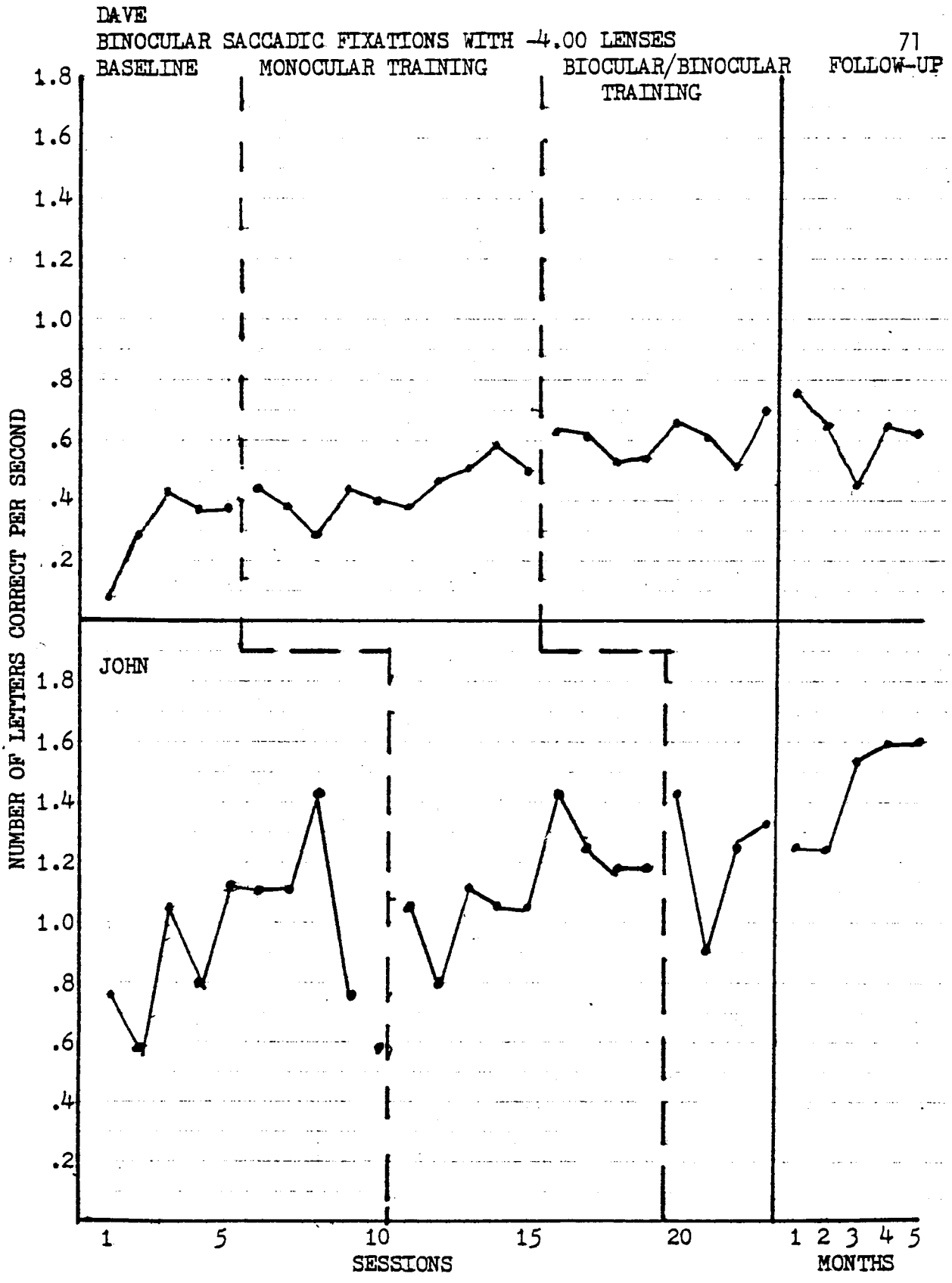


Figure 12. Number of letters correct per second exhibited by each student on the Binocular Saccadic Fixation assessment procedure while wearing -4.00 lenses.

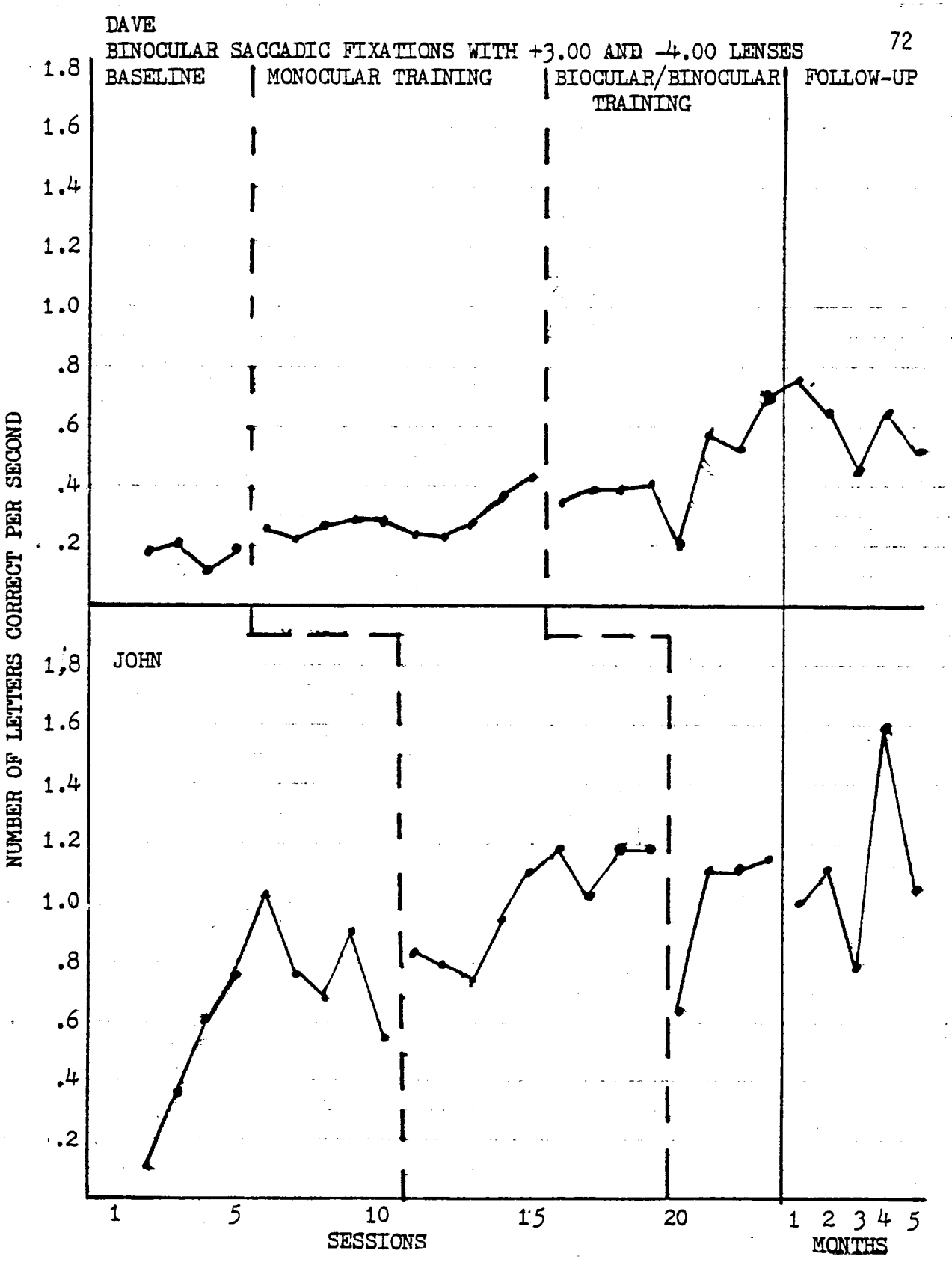


Figure 13. Number of letters correct per second exhibited by each student on the Binocular Saccadic Fixation assessment procedure while wearing +3.00 and -4.00 lenses.

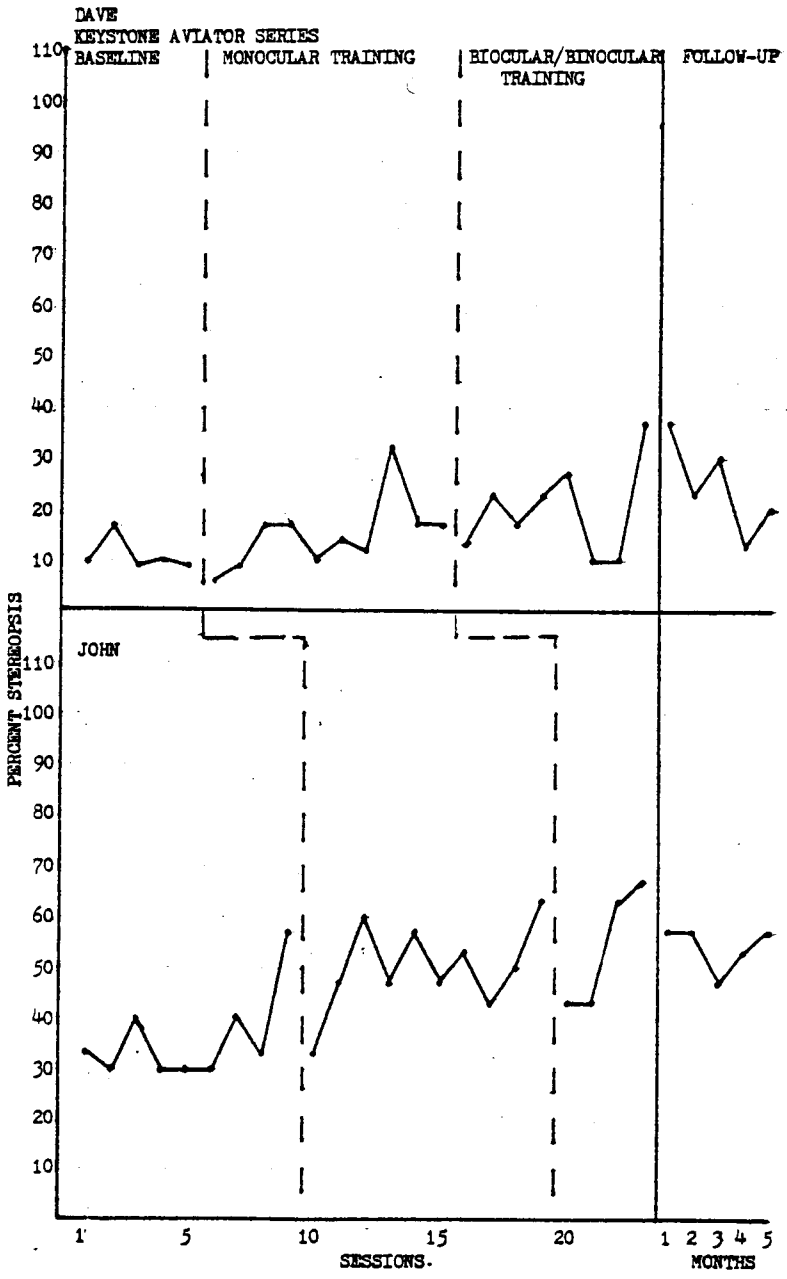


Figure 14. Percent steropsis scored by each student on the Keystone Aviator Series.

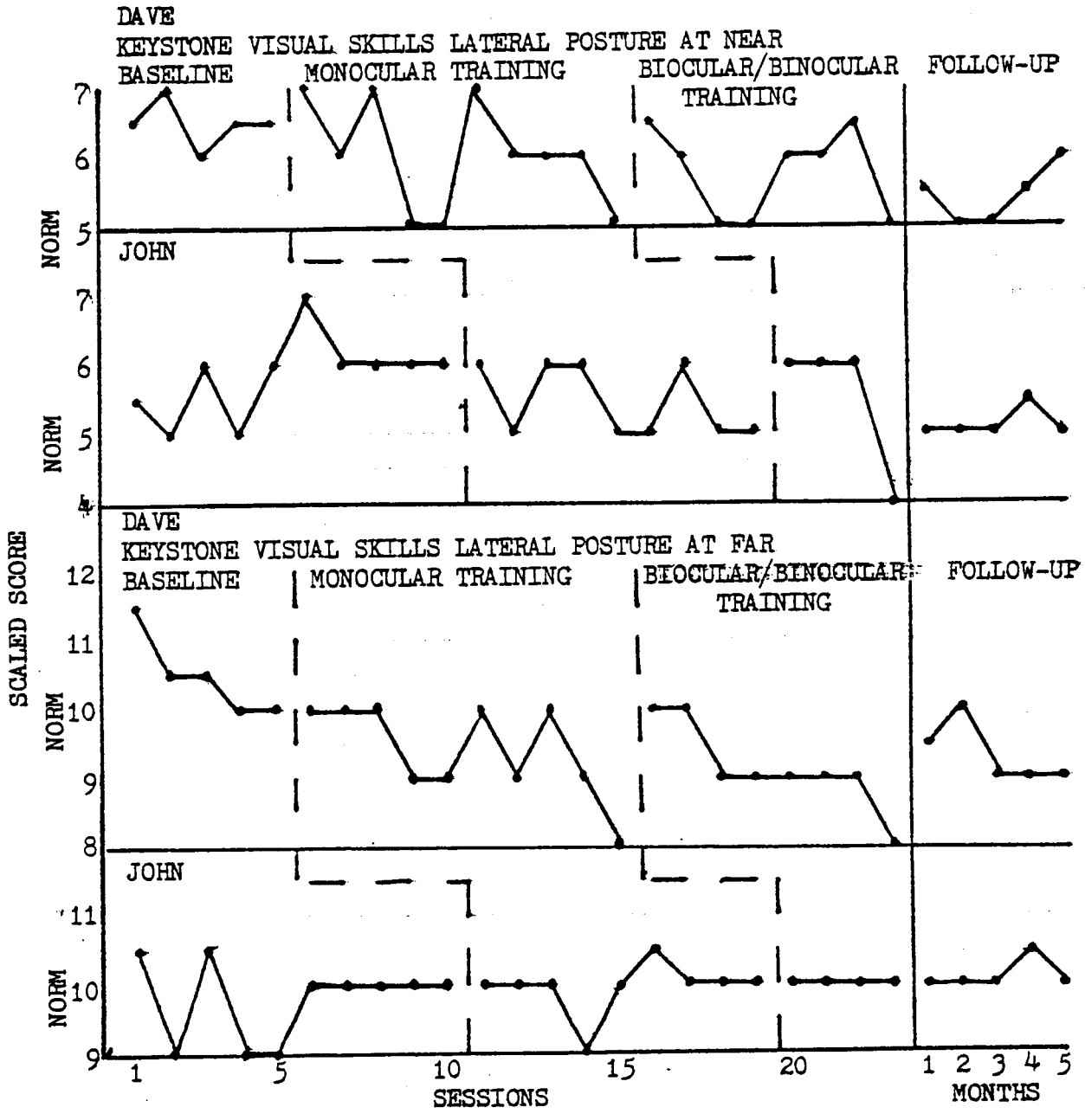


Figure 15. Scaled scores for the Keystone Visual Skills Lateral Posture assessment procedure for near and far point.

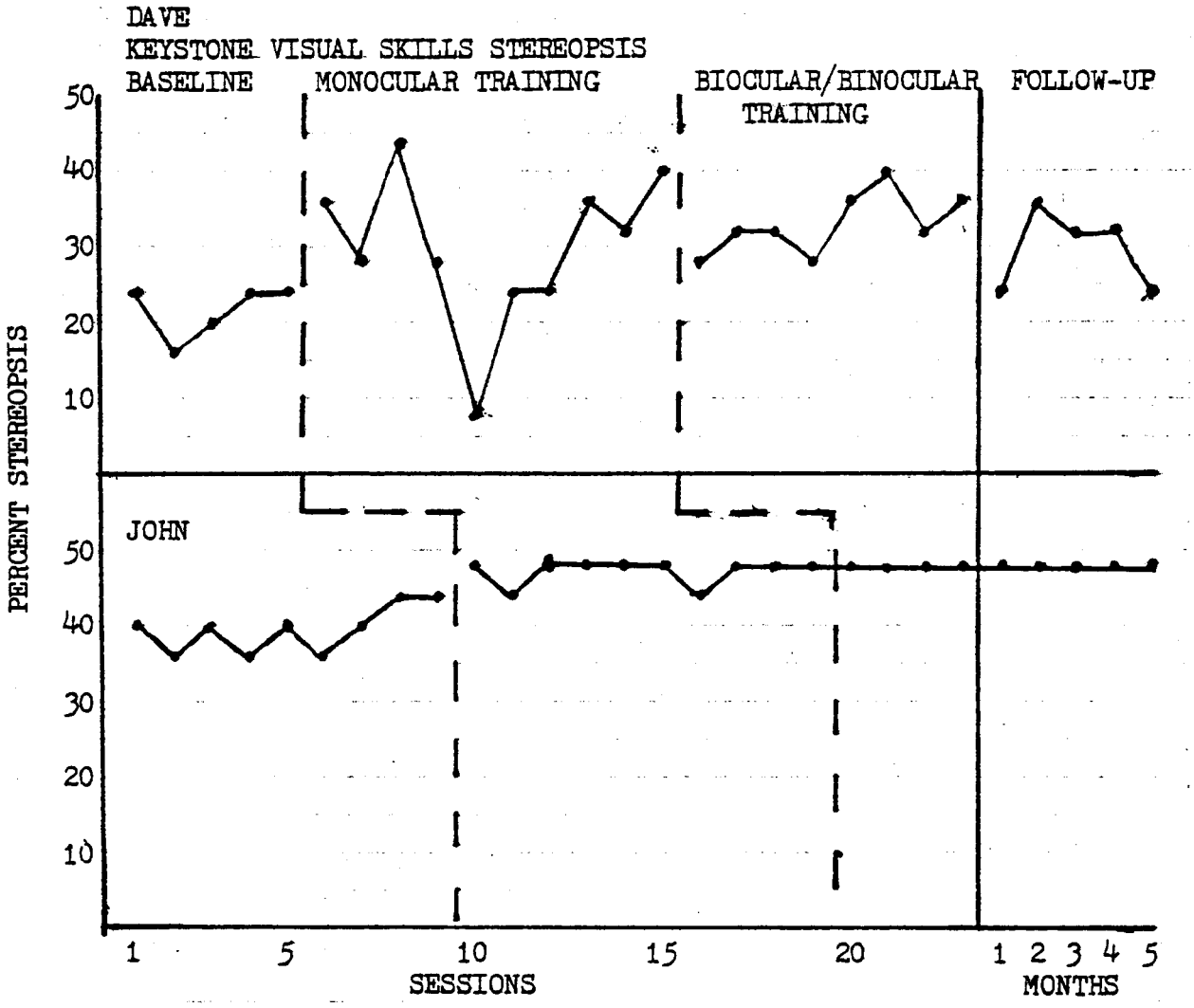


Figure 16. Percent steropsis scored by each student on the Keystone Visual Skills Stereopsis assessment procedure.

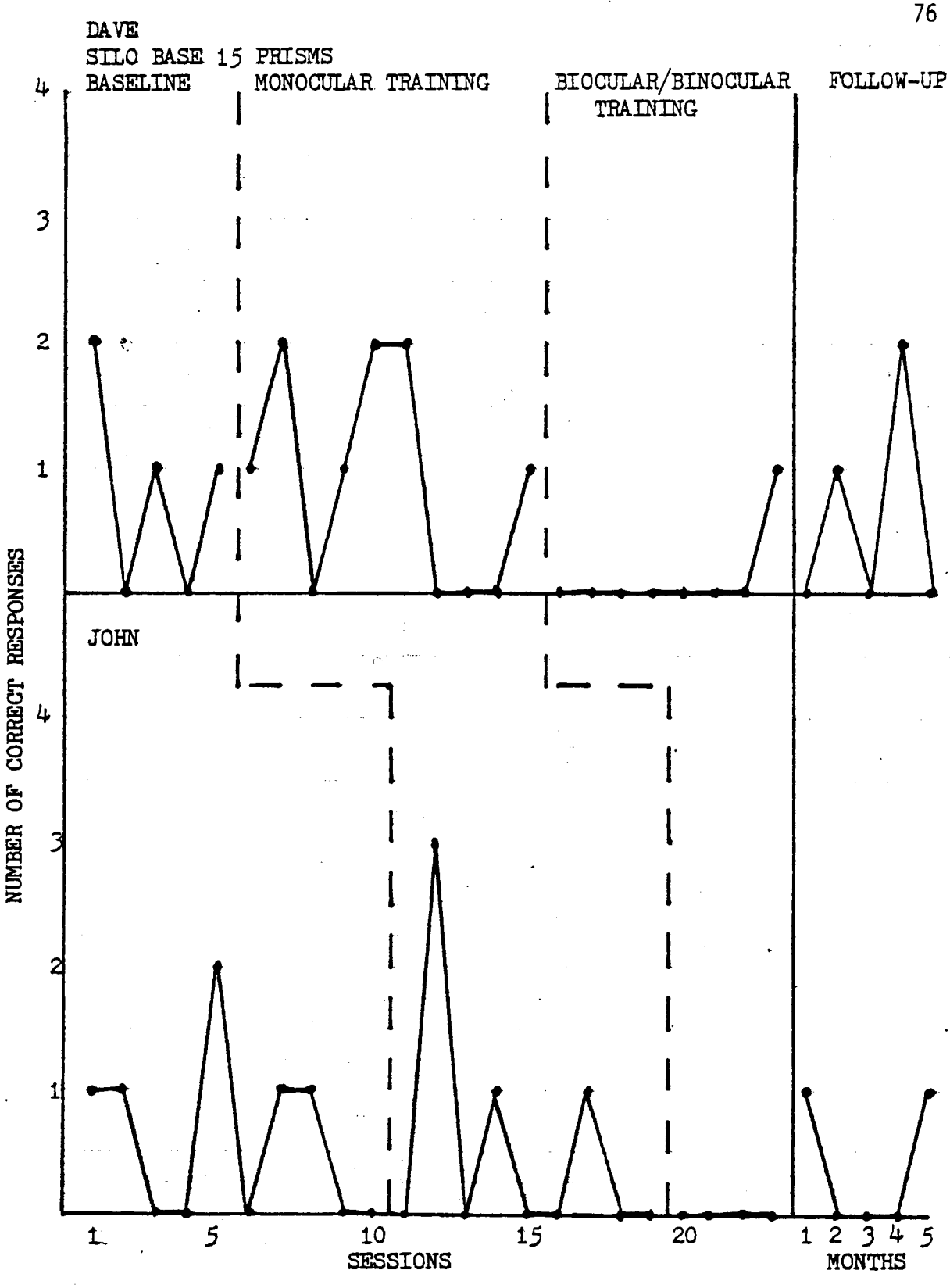


Figure 17. Number of correct responses made by each student on the SILO Base 15 Prism assessment procedure throughout the experiment.

John's baseline, although fluctuating to begin with, stabilized during the last six data points. Monocular training and biocular/binocular training performances were clearly above baseline, except for one data point. Follow-up performance fluctuated at or above the original baseline level with a mean score higher than baseline but lower than the treatment phases.

The introduction of vision training resulted in increases in performance over baseline levels for both boys. Changes for Dave were gradual and delayed, while changes for John were immediate.

Binocular Saccadic Fixations +3.00 Lenses (Figure 11, page 70). Dave showed what appeared to be no change between a stable baseline and monocular training. During biocular/binocular training a slight change resulted after the fifth data point. An upward trend continued in follow-up.

John exhibited a stable baseline after the second data point. Monocular training fluctuated intermittantly at or above baseline. Biocular/binocular training performance increased gradually above baseline and monocular training levels. Follow-up scores were variable, at or above baseline levels. For both boys the introduction of vision training resulted in increased performance that was delayed and gradual in nature.

Binocular Saccadic Fixation -4.00 Lenses (Figure 12, page 71). Dave exhibited an increasing baseline to the third data point at which

time the baseline stabilized. Performance increased slightly and gradually during monocular training, biocular/ binocular training, and follow-up.

John initially showed a stable baseline, however, after the sixth data point the baseline showed a decrease in performance. Monocular training and biocular/binocular training data points increased gradually while fluctuating at or above baseline. Follow-up data points continued to increase above baseline and treatment levels. For both boys the introduction of vision training resulted in performance increases. These increases were gradual and delayed.

Binocular Saccadic Fixations +3.00 and -4.00 (Figure 13, page 72). After a fairly stable baseline for Dave, the introduction of treatment resulted in an immediate slight increase in performance above baseline levels. A continued gradual increase in performance resulted in monocular training, biocular/binocular training and follow-up conditions.

John exhibited an increasing baseline that then stabilized. Treatment data points were slightly above or equal to previous baseline data points. Follow-up performance was equal to baseline levels with higher than baseline levels during the last two data points in follow-up. In both cases slight increases in performance were exhibited during treatment and follow-up conditions.

Keystone Aviator Series (Figure 14, page 73). Dave showed a stable baseline with a fluctuating but gradual increase in performance during monocular training. Biocular/binocular training was quite variable, that is the data points varied between baseline levels and above monocular

training levels. Follow-up scores started at a level above monocular training and equal to the highest biocular/binocular training score and gradually decreased to slightly above baseline levels.

John exhibited a gradual increase in scores in the latter half of baseline with a drop and gradual increase of scores during biocular/binocular training. At the initiation of biocular/binocular training, a decrease in scores resulted with a gradual rise in scores above baseline and monocular training levels. A decrease in scores to approximately monocular training levels were exhibited during follow-up. For both boys fluctuation in scores and gradual and delayed increases in (depth perception) performance were evidenced.

Keystone Visual Skills Lateral Posture Near Point (Figure 15, page 74). A fairly stable exophoric (outward eye stance) was exhibited by Dave during baseline. Monocular training and biocular/binocular training were quite variable with scores ranging from the higher exophoric baseline scores to a normal eye stance. Follow-up scores were more stable than treatment scores with increases in exophoria during the last two points in follow-up.

John exhibited a fairly stable baseline except for one data point showing higher exophoria. Monocular training and biocular/binocular training were similar to baseline levels (correct eye stance or slight exophoria) with only the last point of biocular/binocular training showing some esophoria. John's follow-up performance was stable exhibiting a correct eye stance. Although positive changes in eye posture were not

readily evident for either boy during treatment, follow-up scores showed overall more stability and better eye stance than baseline or treatment conditions.

Keystone Visual Skills Lateral Posture Far Point (Figure 15, page 74). Dave showed a decreasing baseline initially showing exophoria (outward eye stance) followed by a correct eye stance. Monocular training and biocular/binocular training were similar in that they showed either a correct eye stance or slight to moderate degrees of esophoria (inward eye stance). Slight esophoria was exhibited during the last three points of follow-up.

John exhibited an initially variable baseline which stabilized in the latter five points at a normal eye stance. Monocular training was initially stable with variability in both the exophoric and esophoric direction and stability at a normal eye stance for the last three data points. This stability continued into biocular/binocular training and follow-up.

Keystone Visual Skills Stereopsis (Figure 16, page 75). Dave exhibited a gradually increasing baseline with an increase in performance during the beginning of monocular training. Interestingly a decrease in performance below baseline levels occurred mid-monocular training and a gradual increase above baseline occurred during the last three data points of monocular training. Biocular/binocular training and follow-up scores were all above baseline levels with a gradual stable increase in performance during biocular/binocular training. A variable performance at or above baseline levels occurred during follow-up.

John gradually increased in performance during baseline beginning with the sixth data point. The increase continued into monocular training at which time John received a perfect score on the instrument. Perfect scores resulted on all data points except two in monocular training, biocular/binocular training, and follow-up.

SILO Base 15 Prism (Figure 17, page 76). Neither student responded in a manner indicating the acquisition of SILO on this procedure during baseline, intervention or follow-up conditions. For both students variable responses were exhibited in baseline and monocular training. During biocular/binocular training, both students exhibited almost no correct responses to the presentation of the four base 15 prism glasses. Continued incorrect responding occurred during follow-up for both students.

Academic and Visual-Motor Skills Assessed

The results of the following assessment procedures can be found in Figures 18-24 and Table 5, page 52.

Coding Task (Figure 18). Dave exhibited a stable baseline performance with immediate changes in performance when treatment was introduced. Continued gains resulted across monocular training and biocular/binocular training. A slight decline resulted during follow-up, although the performance was still well above baseline levels.

John exhibited an erratic baseline performance with initial gains and then a decline. An immediate increase in performance resulted with

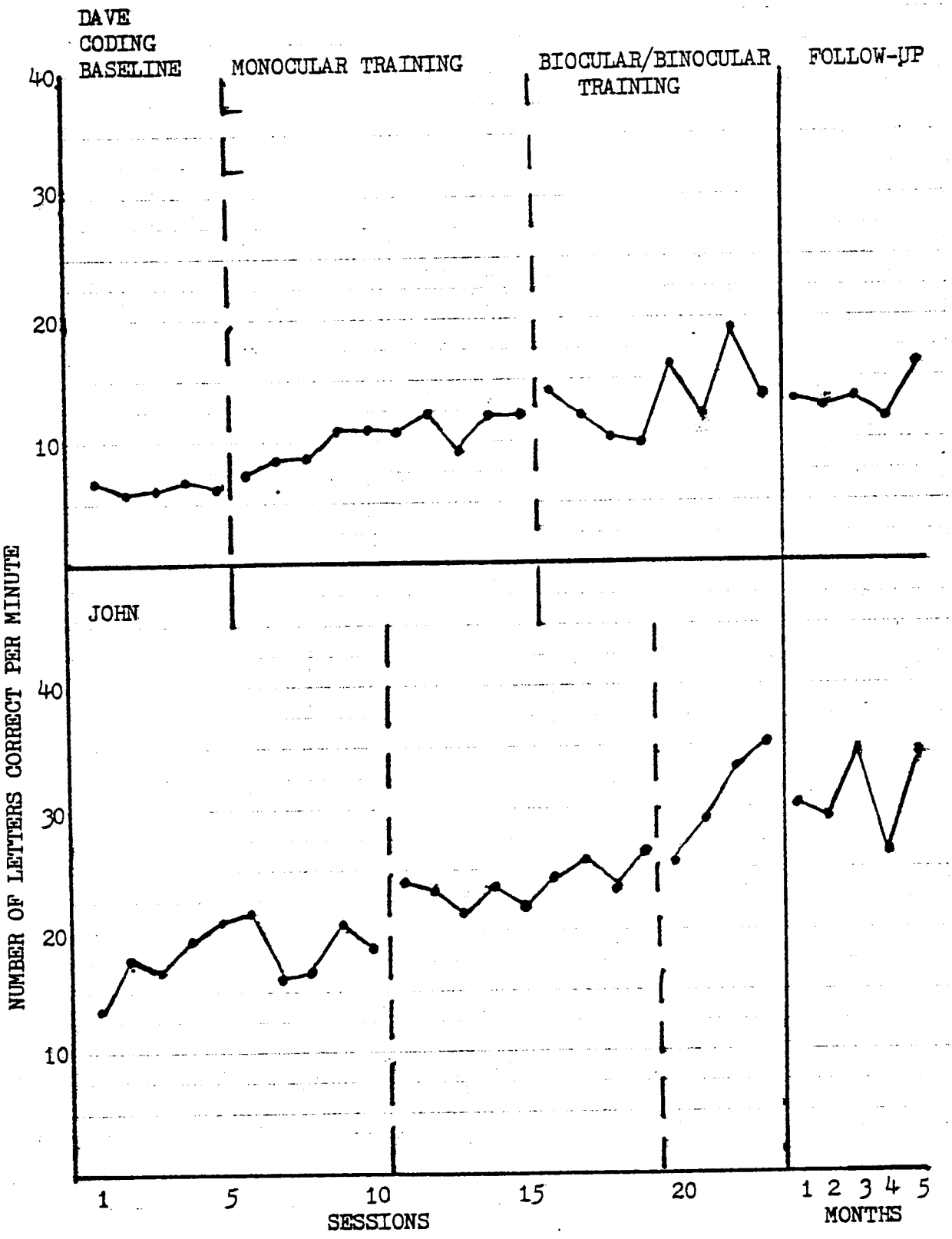


Figure 18. Number of letters correct per minute each student scored on the coding task throughout the experiment.

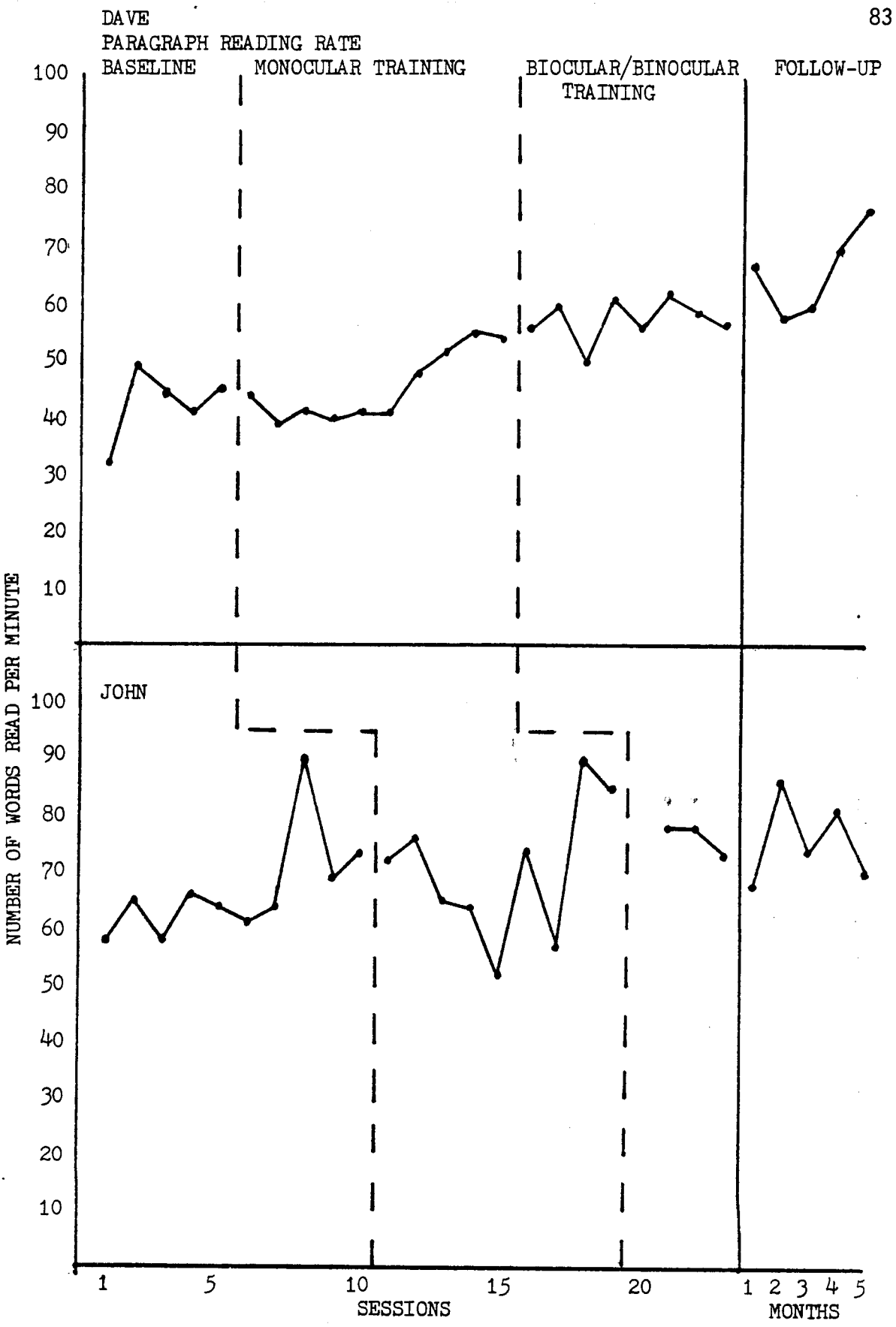


Figure 19. Reading rate of each student throughout the Paragraph Reading assessment procedures.

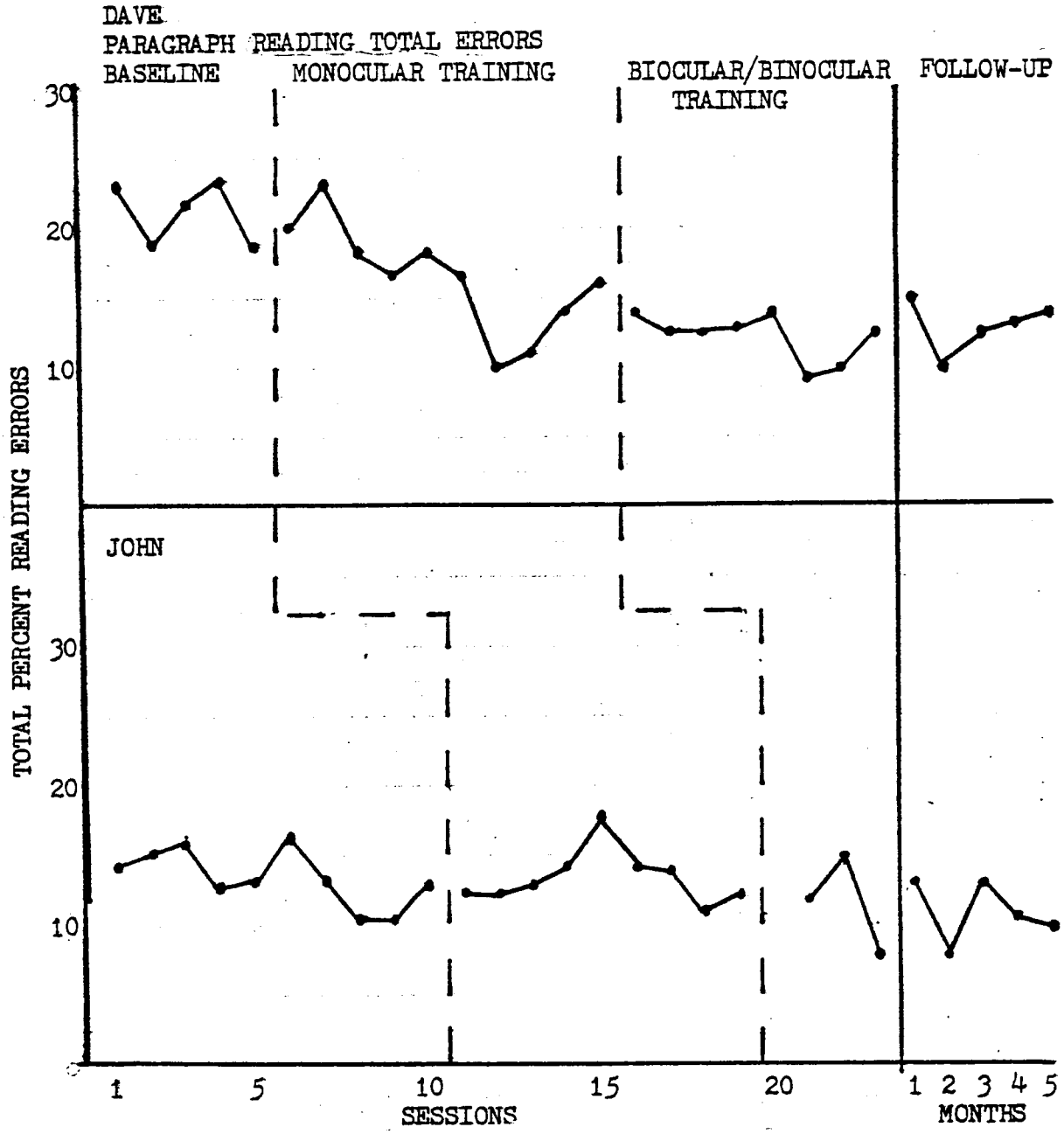


Figure 20. Total percent reading errors for each student throughout the Paragraph Reading assessment procedure.

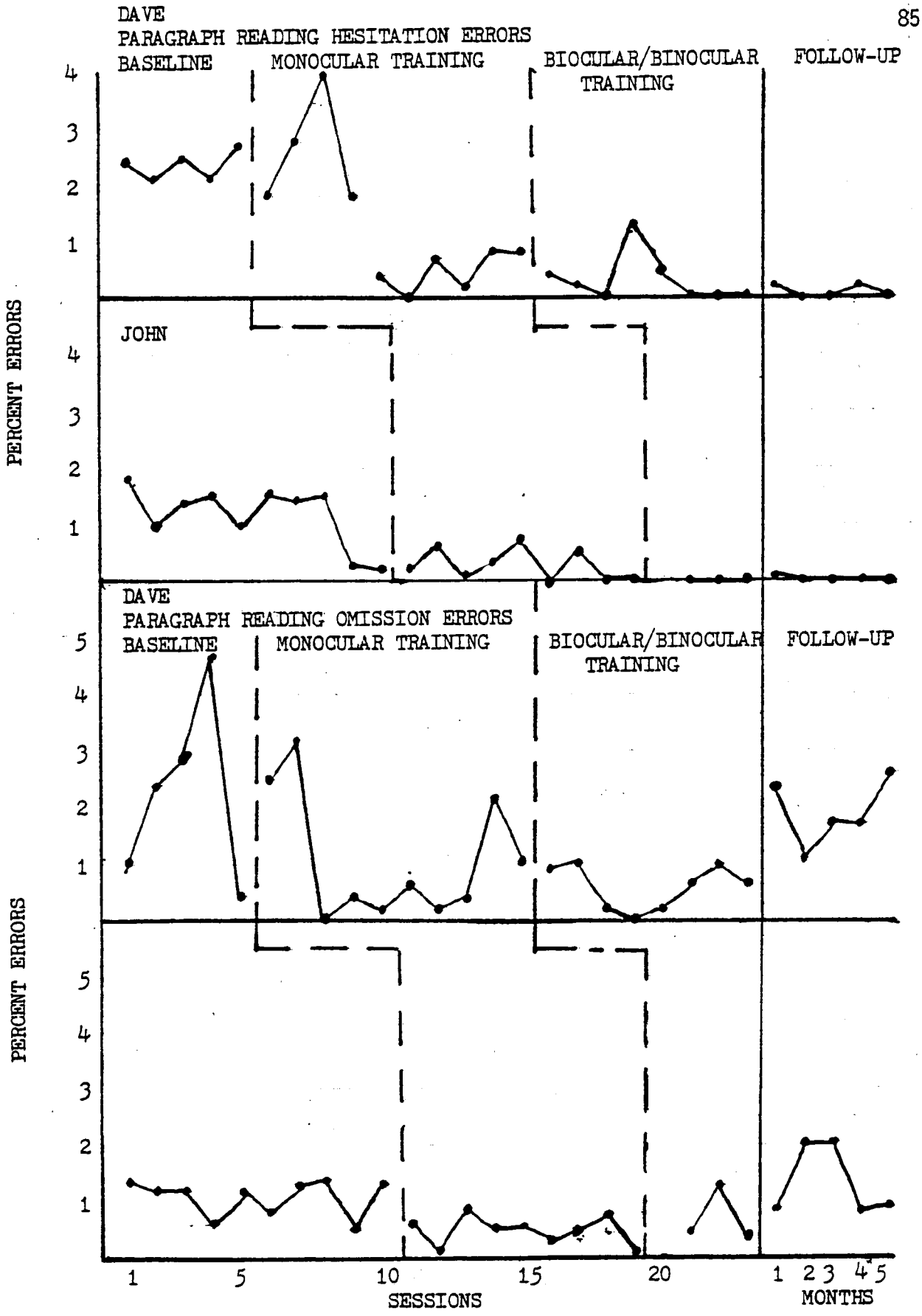


Figure 21. Hesitation errors and omission errors exhibited by each student throughout the Paragraph Reading assessment procedures.

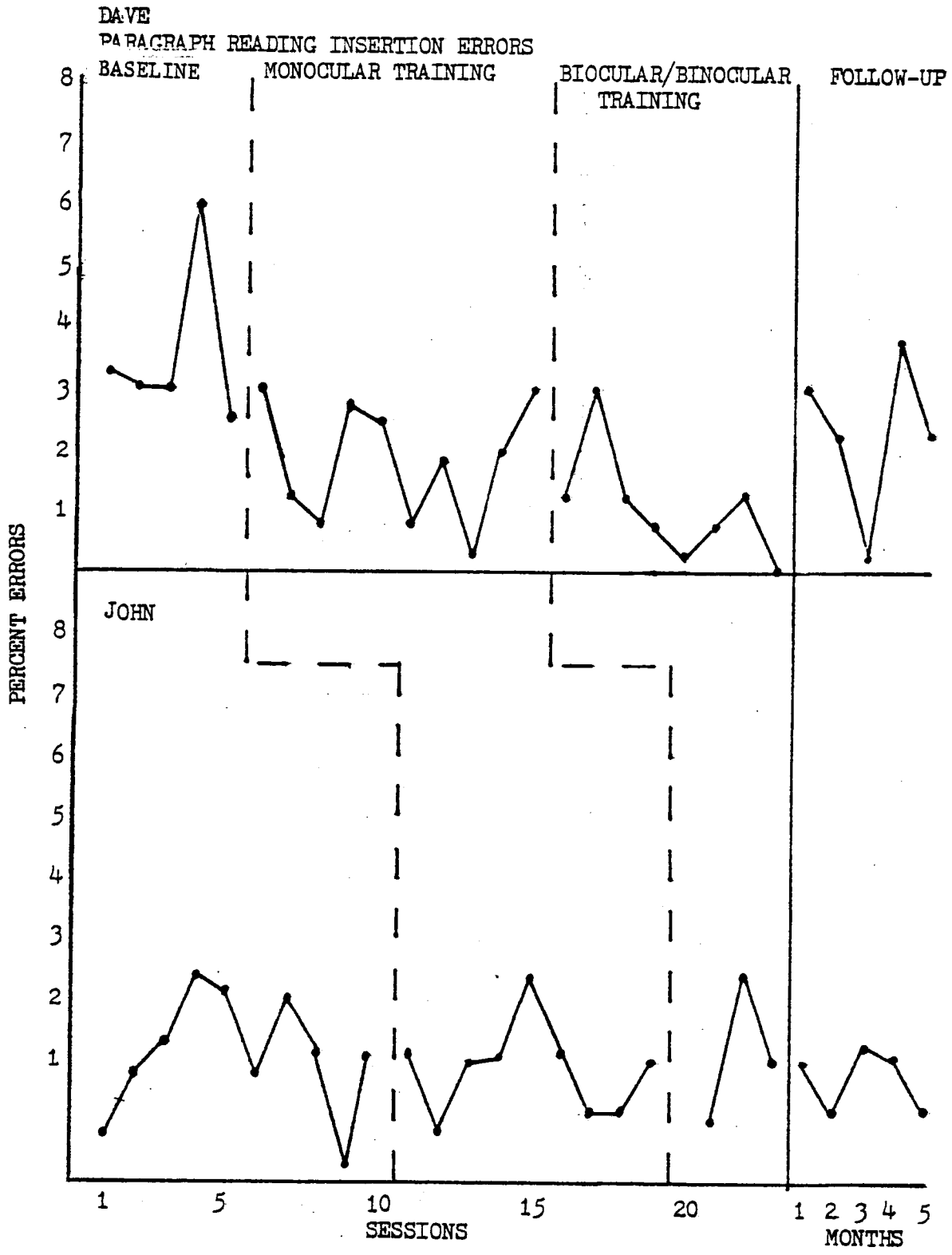


Figure 22. Insertion errors exhibited by each student throughout the Paragraph Reading assessment procedures.

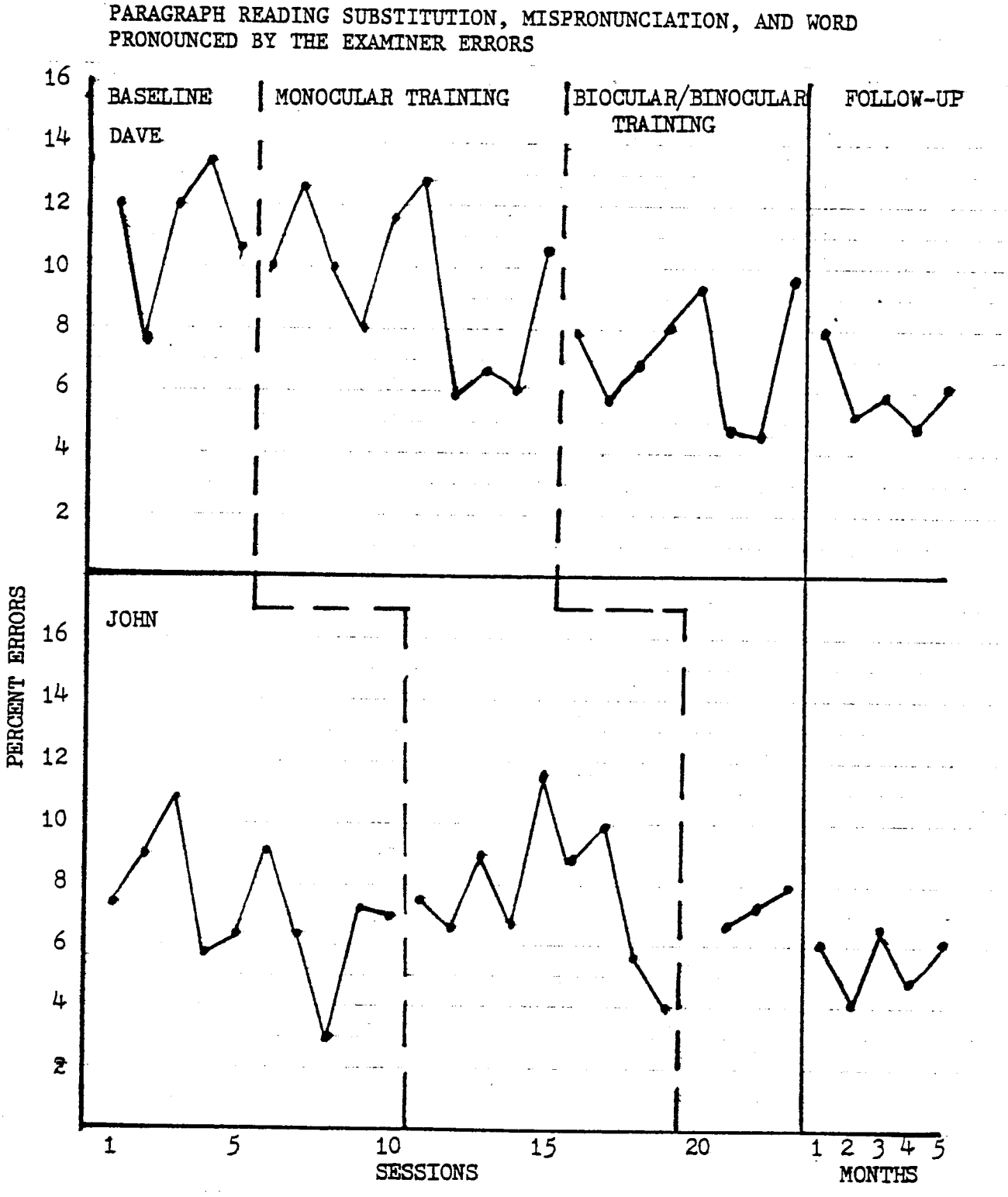


Figure 23. Substitution, mispronunciation, and word pronounced by the examiner errors exhibited by each student throughout the Paragraph Reading assessment procedures.

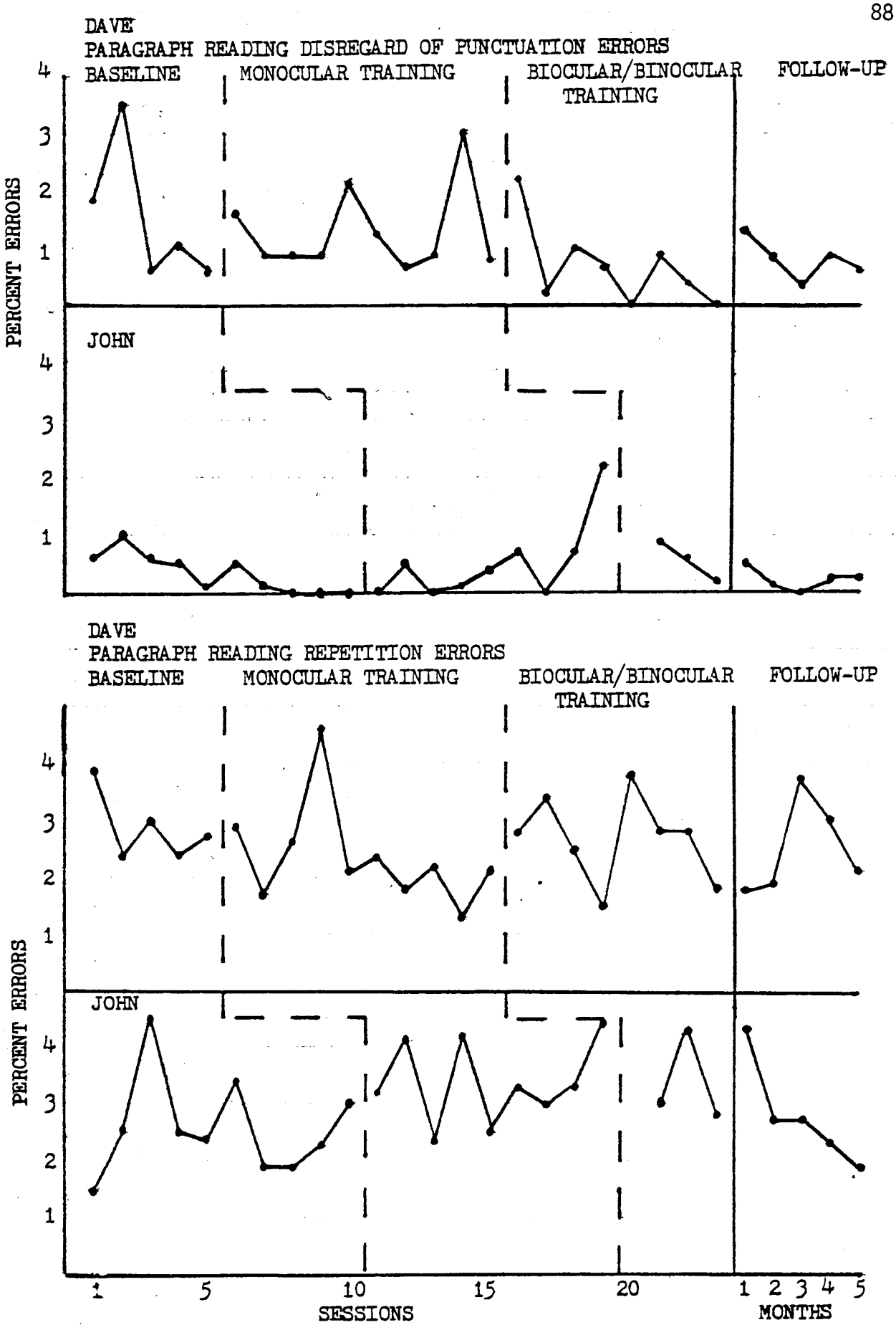


Figure 24. Disregard of punctuation and repetition errors exhibited by each student throughout the Paragraph Reading assessment procedures.

the advent of treatment with continued gains throughout monocular training and biocular/binocular training. For both boys the follow-up resulted in a slight performance decline, however, the data points were well above baseline levels. In both cases, the introduction of vision training resulted in considerable increases over baseline levels. Dave's changes were obtained without corresponding changes in John's baseline.

Paragraph Reading--Reading Rate (Figure 19, page 83). Dave exhibited an initially increasing then stable baseline. After the sixth data point, Dave's performance increased above baseline levels. Performance continued to gradually increase in biocular/binocular training and follow-up conditions. After a gradually increasing baseline, John's overall reading rate initially decreased then increased above baseline levels after the sixth data point in monocular training. Biocular/binocular training performance was slightly above baseline levels, with variable performance above or at baseline levels during follow-up. Changes in Dave's performance resulted without corresponding changes in John's performance.

Paragraph Reading--Total Error Rate (Figure 20, page 84). After a stable baseline, Dave's percentage of reading errors dipped below baseline levels after the third data point in monocular training. A continued decrease in the overall percentage of errors continued in monocular training and stabilized at lower than baseline levels in latter monocular training, biocular/binocular training, and follow-up conditions. After

a stable baseline, no obvious differences in John's performance were found in monocular training, biocular/binocular training and follow-up conditions. Dave's changes were observed without corresponding changes in John's performance.

Paragraph Reading--Rate of Hesitation Errors (Figure 21, page 85). After a stable baseline performance, John's rate of hesitation reading errors decreased below baseline levels after the fourth data point in monocular training and continued below baseline levels to the almost zero error rate during latter biocular/binocular training and follow-up conditions. After a stable then decreasing rate of error in the last two data points in baseline, John's performance continued at the latter baseline levels, until the last two points of monocular training. The rate of error during these points continued on into biocular/binocular training and follow-up conditions at the zero level.

Paragraph Reading--Rate of Omission Errors (Figure 21, page 85). Dave's baseline error rate was initially increasing with a sharp decrease during the last data point in baseline. In the monocular training and biocular/binocular training conditions, a sharp decrease in the rate of error occurred, however, performance was variable. The error rate during follow-up was at baseline levels. After a fairly stable baseline, John exhibited a sharp decrease in errors immediately beginning with and continuing into monocular training. During biocular/binocular training, the error rate was variable, at or below baseline levels. The rate of error during follow-up was at or above baseline levels.

Paragraph Reading--Rate of Insertion Error (Figure 22, page 86). Dave's rate of insertion errors was variable and slightly decreasing during baseline. Monocular training performance was variable and slightly decreasing during baseline. This continued into the first three data points in biocular/binocular training at which time Dave's error rate decreased gradually to the zero level. Performance during follow-up was variable, at or below baseline levels. John's error rate was variable across all conditions, with no apparent treatment effects.

Paragraph Reading--Rate of Substitution, Mispronunciation, and Word Pronounced by the Examiner Errors (Figure 23, page 87). After a variable baseline, Dave's rate of error decreased gradually during monocular training, biocular/binocular training and follow-up conditions. However, during each of these conditions, performance was variable. John's rate of error was also variable during baseline, with continued variability in monocular training, biocular/binocular training and follow-up conditions. Performance at the lowest level of baseline was exhibited during the follow-up condition.

Paragraph Reading--Rate of Disregard of Punctuation Errors (Figure 24, page 88). After a variable baseline, Dave exhibited no treatment effects during the monocular training condition. Biocular/binocular training and follow-up performance were variable, at or below baseline. After a gradually decreasing baseline to the zero error rate, John's error rate increased above baseline levels in monocular training and then gradually decreased to baseline levels in biocular/binocular training and follow-up conditions.

Paragraph Reading--Rate of Repetition Errors (Figure 24, page 88). After a stable baseline, Dave's rate of repetition errors decreased below baseline levels after the fifth data point in monocular training. Biocular/binocular training and follow-up performance were however at baseline levels. John's performance was variable across all conditions, with no changes in performance observed during treatment conditions. During follow-up, the percentage of repetition errors steadily decreased to the lowest baseline level.

Pre-post Assessment Results

The results of before and after assessment procedures are displayed in Table 6. Improvements in performance include general cognition, perceptual-performance (Dave only), quantitative, and memory scales of the McCarthy Scales of Children's Abilities, the Motor-Free Visual Perceptual Test, the Jordan Left-Right Reversal Test (Dave only), the Visual Aural Digit Span Test, the Test of Auditory Analysis (Dave only), the Developmental Test of Visual Motor Integration (Dave only), and the Bender Motor Gestalt Test (John only).

No improvements were observed in the verbal and motor scales of the McCarthy Scales of Children's Abilities by either student.

A number of visual symptoms noted by the student's parents before vision training were no longer evidenced after training procedures utilizing the Educator's Checklist of Observable Clues to Classroom Vision Problems. Positive changes in visual symptomology exhibited by Dave include no longer blinking excessively during desk tasks or rubbing

TABLE 6

RESULTS OF ASSESSMENT PROCEDURES EMPLOYED BEFORE AND AFTER OPTOMETRIC VISION TRAINING

		Dave				John			
		Pre-Assessment	Post Assessment	Mean	Change	Pre-Assessment	Post Assessment	Mean	Change
(1)	Bender Motor Gestalt Test	-	-	-	-	8 years	8.4-9.0 years	-	+.5 years
(2)	Development Test of Visual Motor Integration	6 years 5 mos.	7 years 4 mos.	-	+11 mos.	-	-	-	-
(3)	Jordan Left-Right Reversal Test	6.0-6.5 years	7.6-7.11 years	-	+1.5 year	Age Appropriate	Age Appropriate	-	-
(4)	McCarthy Scales of Children's Abilities:								
	General Cognitive Scale	105	114	100	+9	117	123	100	+6
	Verbal	61	61	50	0	57	64	50	+7
	Perceptual-Performance	54	64	50	+10	63	63	50	0
	Quantitative	40	48	50	+8	52	61	50	+9
	Memory	47	63	50	+16	49	60	50	+11
	Motor	42	43	50	+1	63	65	50	+2
(5)	Motor-free Visual Perceptual Test	95 6 years 11 mos.	118 9.0 years+	100	+2 years	103	130	100	+27
(6)	Observable Clues to Classroom Vision Problems Filled Out By Parents - Number of Symptoms Checked	6	2	-	4 less symptoms	11	6	-	5 less symptoms
(7)	Test of Auditory Analysis	Grade 2	Grade 3	-	+1 Grade	Age Appropriate	Age Appropriate	-	-
(8)	Visual Aural Digit Span Test	7.0 years	9.0 years	-	+2 years	9 years	11 years	-	2 years

his eyes during or after these tasks, reduced difficulty when working from the chalkboard, cessation of burning or itching eyes during desk work, a reduction in omitted or repeated words and losing his place while reading, as well as a longer attention span during near point and copying tasks. Changes in the visual symptomology exhibited by John include a cessation of observed squinting and reddened eyes and fewer observances of the use of his finger to keep his place. Visual symptomology still exhibited by Dave include reddened eyes, errors in copying from the chalkboard to the paper on the desk, and holding his book or paper too close to his face while performing near points tasks. Visual symptoms still exhibited by John include occasionally holding his book or paper too close to his face while performing near point tasks and occasionally complaining of discomfort in tasks that demand visual interpretation.

CHAPTER IV

DISCUSSION

The results of this study indicate the effectiveness of this optometric vision training package to directly train specific functional visual skills involving accomodation, binocularity, fixational abilities, and pursuits and to improve a specific type of visual-motor functioning without directly training the task. These results can be directly attributed to the optometric vision training package with experimental reliability.

In order for the results of this study to be attributed to the optometric vision training treatment package, a replication of results across both students was necessary. A direct replication across subjects is demonstrated when changes occur in the first subject's performance during treatment without corresponding changes in the second subject's baseline and the second subject then replicates the treatment effects observed in the first subject. Eighty-three percent of the standard training procedures assessed, 0 percent of the standard optometric assessment procedures employed, 0 percent of the reading skills assessed, and 100 percent of visual-motor skills assessed were replicated. These findings indicate that replications occurred exclusively in those skills directly trained and the visual-motor task, with a possible replication on a specific type of reading error.

Skills assessed included accommodation, binocularity, fixations, lateral posture, pursuits, reading, visual memory, and visual-motor skills. Replication of positive treatment effects occurred in directly training specific functional vision skills involving accommodation, binocularity, fixations, and pursuits. Only the visual memory skill as measured by the Tachistoscope assessment procedure was not replicated after being directly trained. The only skill indicating positive treatment effects across subjects through replication that was assessed but not directly trained was fine visual-motor functioning as indicated on the coding task. Specific skills assessed but not directly trained involving fixational abilities, accommodative abilities, binocularity abilities, lateral posture, and specific reading skills did not show improvements that were replicated across subjects.

The results obtained in this study were consistent with findings of other studies on optometric vision training. The improvements on the coding task were consistent with grapho-motor improvements observed in the Jens (1970) and Ryan (1973) studies. Although replications were not evidenced on paragraph reading, improvements during the course of training were evident and appear consistent with the numerous studies indicating reading improvements through optometric vision training. (Coleman 1972, Friedman, 1974, Halgren 1960, and Young 1971). Changes in binocularity would also be similar to changes observed in the Ryan study. Pre-post assessment results in this study were consistent with the majority of the literature on optometric vision training in terms of improved cognitive, grapho-motor, and visual perceptual skills.

What this study indicated that was not apparent in previous studies is the specific changes that occurred in visual performance as a result of the optometric vision training procedures over time. These findings were obtained in an optometric vision training practice. The only other controlled study that occurred in an optometric vision training facility was performed by Weisz (1979). However, Weisz' study dealt with the training of specific accommodative functions and their effect on a paper-pencil task, not the evaluation of a complete optometric vision training package.

This study appears to be the only research with empirical controls that has measured changes that occurred following the termination of treatment. Of the improvements observed in visual, reading, and visual-motor behaviors, approximately 80 percent were maintained above baseline levels during the five month follow-up. Eighty-eight percent of the improvements observed in the repeated measures directly trained were maintained above baseline levels during the five month follow-up.

The overall results of this study indicate that for both students a number of positive changes occurred during the course of treatment. Some of these improvements occurred without replication across subjects. Due to the lack of experimental controls, these improvements cannot be reliably attributed to the optometric vision training package.

Improvements occurred in the direct training of the visual memory skill and in those skills assessed but not directly trained including lateral posture, reading abilities including specific types of errors and

reading rate, accommodation, binocularity, and fixational abilities. It is interesting that the types of reading improvements exhibited appeared qualitatively different than the types of reading improvements that one would expect to occur in a remedial reading approach. For example, in this study the most prevalent improvements occurred in reading rate and decreased omission and hesitation errors. It could be hypothesized that a remedial reading approach would have the greatest effect on words the student did not know and substitution and mispronunciation errors versus improvements on hesitation and omission errors.

At present the discrepancy between improvements observed and the results that can be experimentally attributed to the optometric vision training package via replication procedures cannot be fully explained by this study. The above discrepancy could be due to a number of factors that include differences within each student that make optometric vision training procedures more or less effective, the lack of experimental procedures to control for delayed treatment effects, the use of dependent measures that are possibly unreliable, and effects related to uncontrolled variables outside of the experiment proper.

Individual Differences

Although both students entered optometric vision training with a similar optometric diagnosis, individual performance differences were evident throughout the training process. Each student entered and finished optometric vision training with different levels of visual skills. Overall, John performed at a higher level than Dave. However on a few

specific tasks, Dave performed at a higher level than John. Although the individual differences on performance are evident, these differences are difficult to explain with reliability. On the Quoit Base In and Base In Recovery task, Dave performed better than John. On this task the students were required to learn to turn their eyes out while using them in a binocular fashion. This could perhaps be explained by Dave's initial diagnosis of exophoria at far (outward eye stance) versus John's initial diagnosis of esophoria at far (inward eye stance). It is possible that it would be easier for Dave to learn to turn his eyes to a posture in which his eyes were already in that general direction.

Delayed Effects

In this study, 53 percent of the total percent of dependent measures that improved occurred immediately after the onset of training. In that only two subjects participated, only immediate training effects could be replicated, defined in this study as effects occurring within the first five data points after the onset of training. Eight percent of the total percent of dependent measures that improved during training occurred in the latter half of monocular training, 17 percent in the biocular/binocular condition, and 9 percent in the follow-up condition. The combined total of the delayed improvements (34 percent) that occurred after the immediate onset of training were not controlled for. Therefore these improvements cannot be explained by this study and be reliably attributed to the overall effects of the treatment package.

Questionable Instrumentation

The results of this study lead to questions regarding the reliability of specific standard optometric assessment procedures to measure visual behaviors over time. The utility of assessment procedures are questionable if these procedures are not sensitive to changes due to training, unreliable in exhibiting performance changes, excessively variable or easily learned when repeated over time. The Base 15 SILO is an instrument with questionable performance. Neither student acquired the correct discrimination throughout baseline or training. The results appear descrepant with the increased binocular functioning exhibited by both students and the almost immediate acquisition of SILO on the Quoits and the Adapted Robbin's Rock training procedures. It is possible that either the acquisition of SILO with the base 15 prisms is a higher level skill not attained by either student or the Base 15 SILO assessment procedure was not a reliable indicator of binocularity for the two students.

In 15 percent of the total percent of dependent measures that improved during this study, the improvements began in the baseline condition and continued gradually into the treatment conditions. Such improvements could result from a number of reasons including the learning of assessment procedures through performance of these procedures over time, improvements due to the special treatment provided during baseline (Hawthorne Effect), performance changes due to generalization of results from other training procedures, and/or spurious effects due to variables outside the control of the experiment. Assessment procedures in which gradually improving baselines occurred for both students were Lateral

Posture at far point and Binocular Saccadic Fixations with -4.00 lenses. Lesser degrees of power in the lenses employed on the Binocular Saccadic Fixation assessment procedure may make this task more sensitive in measuring changes in accommodation that may occur due to treatment.

The lack of results that were replicated using standard optometric assessment procedures, also leads to questions regarding the utility of these assessment procedures in single case experimental methodology. Although the reliability of specific assessment procedures discussed above are questioned, this study provides only limited suggestive information regarding the utility of these instruments as repeated measure assessment procedures.

Extraneous Uncontrolled Variables

Circumstances that occur outside of treatment and are not controlled by the experiment can have effects upon the results. A possible instance of an extraneous effect could have been John's drastic increase in reading rate and drop in reading errors on the eighth data point. Reviewing a journal describing the session indicated that neither student was in school that day and that John stated that he had a hard time at play school and was looking forward to coming to vision training. The lack of visually demanding work combined with his added enthusiasm for participating in vision training could possibly account for his better than average baseline reading scores on that particular day.

Pre-post data, parent and school reports also lack experimental controls, however can provide additional information regarding changes

that were observed or perceived over the course of the study. A reduction in the number of symptoms related to visual problems as perceived by both sets of parents before and after optometric vision training is suggestive of a reduction of visual stress during the course of training. Dramatic improvements were observed in a number of skills in pre- and post-assessment including skills that were visual perceptual, cognitive, memory related, and academic in nature. Improvements greater than the expected by both students on skills requiring concentration and attention such as visual perceptual, memory, and quantitative skills are suggestive of an increased ability to concentrate and attend.

Although no changes were readily evident in John's overall school performance (he continued to make his school's honor roll), Dave made a number of improvements in school during and after optometric vision training. For instance, his grades improved remarkably the grade period after the onset of training and were maintained during follow-up. Initially, Dave was not completing his work in school at the onset of the study. On the eighth training session his mother reported that he finished his work for the first time. By the end of training, he finished his work almost every day. However, it was not until the last month of follow-up at which time he consistently finished his work on time. Again these changes cannot be reliably attributed to the optometric vision training package because of the lack of experimental controls, although these results suggest the possibility that certain treatment effects for each student may have generalized outside the realm of the optometric practice.

The use of the results of this study in attempting to answer a number of predictive questions appears limited. For example, questions regarding the generalization of results to other students, therapists, and settings need to be viewed from the standpoint that one therapist worked with two students in one specially designed setting and that generalization to other students and therapists in other settings cannot at this point be reliably inferred. Further replication across students, therapists, and settings is necessary to reliably make such generalizations. Other questions such as the optimal period for termination of treatment or optimal length of training can also not be predicted from this study.

One of the findings that stands out from this particular research project is the need for future research to further delineate the effects of optometric vision training. There appears to be a need for a pragmatic and systematic approach in evaluating optometric vision training. The single case experimental design appears to be an effective methodology for evaluating optometric vision training in an optometric practice.

The development of reliable and valid repeated measure assessment procedures to directly assess the specific effects of optometric vision training is of importance in more fully understanding the optometric vision training process and variables that increase the efficacy of training procedures utilized.

Specific suggestions for future research include the employment of feedback in the Tachistoscope training activity after each slide instead

of after all ten slides. Research on immediate versus delayed feedback indicates that immediate feedback is a much more powerful tool in learning and remembering than delayed feedback. The switch to immediate feedback on the Tachistoscope activity in other cases in office supports these findings.

Future research could employ replication strategies to develop a systematic and comprehensive research program to evaluate optometric vision training experimentally. This methodology could be performed in the private practices of cooperating optometrists with benefits to the participants and others in need of such treatment, as well as the cooperating optometrists and researchers.

The delayed treatment effects encountered in this study could be controlled for by simply incorporating a third and perhaps a fourth student with longer baseline periods. The participation of additional students could also begin to suggest differential treatment effects due to specific student characteristics. Similarly, additional students in other settings with different therapists would increase the generalizability of the findings across students, settings, and therapists. This research would further evaluate the effectiveness of specific assessment procedures to reliably and repeatedly measure visual and academic performance over time.

The development of behavioral observation systems and/or repeated measure procedures could be employed to measure other areas that may be affected by optometric vision training in addition to those skills measured

in this study. Reliable as well as predictive instrumentation could be developed to measure visual changes as well as changes such as visual symptomology, visual perception, quantitative concepts, grapho-motor/fine motor, and memory/attentional skills and abilities. Research evaluating the effects of optometric vision training on school performance and specific school behaviors including on task behaviors and attention and concentration is also recommended.

BIBLIOGRAPHY

BIBLIOGRAPHY

Baer, D. M., Wolf, M. M., and Risley, T. R. Some current dimensions of applied behavior analysis. Journal of Applied Behavior Analysis, 1968, 1, 91-97.

Bergin, A. E., and Strupp, H. H. Changing Frontiers in the Science of Psychotherapy. New York: Aldine-Atherton, 1972.

Coleman, H. M. The West Warwick visual perception study - Part I. Journal of the American Optometric Association, 1972, 43(4), 456-562(a).

Coleman, H. M. The West Warwick visual perception study - Part II. Journal of the American Optometric Association, 1972, 43(5), 532-544(b).

Friedman, N. Reading disability: A fusional-eye movement disability? Journal of the American Optometric Association, 1974, 45(6), 727-732.

Gilmore, J. B. and Gilmore, U. C. Gilmore Oral Reading Test Manual of Direction. New York: Harcourt Brace and World, Inc., 1968.

Greenspan, S. B. Research Studies of Visual and Perceptual-Motor Training. Duncan, Oklahoma: Optometric Extension Program Foundation, 1972.

Greenspan, S. B. Annual review of literature in developmental optometry: Report of the C.O.V.D. Council on Research Programs. Journal of Optometric Vision Development, 1976, 7(4), 5-69.

Greenspan, S. B. Annual review of literature in developmental optometry: Report of the C.O.V.D. Council on Research Programs. Journal of Optometric Vision Development, 1978, 9(1), 9-81.

Halgren, M. R. Opus in see Sharp. Education, 1960-1961, 81, 369-371.

Halgren, M. R., Getman, G. N., McKee, G. W., and Kane, E. R. The Golden Valley Study. In: The role of the optometrist in the development of perceptual and visumotor skills in children. American Journal of Optometry and Archives of American Academy of Optometry, 1967, 44(5), 297-308.

Halgren, M. R., and McKee, G. W. The Holy family project. In: The role of the optometrist in the development of perceptual and visuomotor skills in children. American Journal of Optometry and Archives of American Academy of Optometry, 1967, 44(5), 297-308.

Halliwell, J. W., and Solan, H. A. The effects of a supplemental perceptual training program on reading achievement. Exceptional Children, 1972, 61(2), 613-621.

Hersen, M., and Barlow, D. H. Single Case Experimental Designs. New York: Pergamon Press Inc., 1976.

Jens, D. Project Genesis: Final report. St. Clair Shores, Michigan Lake Shore and Lake View Public Schools, 1970.

Keogh, B. K. Optometric vision training programs for children with learning disabilities: Review of issues and research. Journal of Learning Disabilities, 1974, 7(4), 219-230.

Ludlam, W. M., Twaroski, C., and Ludlam, D. T. Optometric vision training for reading disability: A case report. American Journal of Optometry and Archives of American Academy of Optometry, 1973, 50(1), 58-66.

Morgan, M. W. The effect of visual perceptual training upon subsequent scholastic progress of children with specific visual difficulties. Duncan, Okalhoma: Optometric Extension Program, 1966.

Rasmussen, D. and Goldburg, L. Basic Reading Series. Chicago: Science Research Associates, Inc., 1969.

Rohr, A. M. A Multi-district Use of Visual Training as an Instructional Approach in Elementary Education. Duncan, Oklahoma: Optometric Extension Program Foundation, 1969.

Ryan, P. J. An experiment in the remediation of reading retardation of first through sixth graders by means of auditory, visual, and/or motoric perceptual therapy. The Report of the Cambrian Project, Unpublished Manuscript, 1973.

Seiderman, A. S. A look at perceptual-motor training. Academic Therapy Quarterly, 1972, 7(3), 315-321.

Shearer, C. W. A study comparing disadvantaged pre-school children's test scores in directionality orientation and sensory concepts fundamental to their reading readiness before and after visual-perceptual-motor training. Duncan, Oklahoma: Optometric Extension Program Foundation, Inc., 1970.

Solon, H. A., and Seiderman, A. S. Case report on a grade one child before and after perceptual-motor training. Journal of Learning Disabilities, 1970, 3(12), 635-639.

Spache, G. D. Diagnostic Reading Scales. Monterey, CA.: McGraw-Hill, Inc., 1972.

Spencer, R. W. Optometrists handling of perceptual motor problems. In: D. B. Carter (Ed.), Interdisciplinary Approaches to Learning Disorders, Philadelphia: Chilton Book Co., 1970.

Swanson. W. Optometric vision therapy-How successful is it in the treatment of learning disorders? Journal of Learning Disabilities, 1972, 5(5), 285-290.

Weisz, C. L. Clinical therapy for accommodative responses: Transfer effects upon performance. Journal of the American Optometric Association, 1979, 50(2), 209-216.

Wilson, W. K., Mack, J. D., Breslouer, A. H. The Coronado project: An identification and remediation visual perceptual training program. Duncan, Oklahoma: Optometric Extension Program Foundation, Inc., 1975.

Wold, R. M., and Challas, J. Why doesn't Johnny read better? In: R. M. Wold (Ed.), Visual and Perceptual Aspects for the Achieving and Underachieving Child, Seattle, Washington: Special Child Publications, 1969.

Wold, R. M., Pierce, J. R. and Keddington, J. Effectiveness of optometric vision therapy. Journal of the American Optometric Association, 1978, 40(9), 1047-1054.

Young, L. M., Kane, B. M., Basile, G., Miller, M. M., Miller, M., and Grant, R. Motor coordination-visual perception study. Duncan, Oklahoma: Optometric Extension Program Foundation, 1971.

VITA

Gary L. Patrick, the son of Mr. and Mrs. Edward F. Patrick, was born on March 28, 1953 in Racine, Wisconsin. He attended elementary and junior high schools in Racine, Wisconsin and graduated from Racine Horlick High School in 1971.

Upon completion of high school, he attended Lawrence University and The University of Wisconsin, Madison, graduating in 1974. While attending college, he spent nine months in Europe studying in Germany and observing institutions for the handicapped in other Western European Countries. After graduation from college, he worked as an activity coordinator in a residential center for developmentally disabled adults and a learning disabilities specialist in a private school for learning disabled children.

In September of 1976, the author enrolled in the doctoral program in school and community psychology at The University of Tennessee, Knoxville, and received his Ph.D. in August, 1979. During graduate studies, he was employed part-time in the optometric vision training practice of J. C. Tumblin, O. D. and served as an intern psychologist for Knoxville City Schools. He is currently certified as a school psychologist and licensed as a psychological examiner in The State of Tennessee.

He is married to the former Sandra Lee Droster of Burlington, Wisconsin and is employed at a mental health center as a psychologist/ consultation and education coordinator.