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The effects of token reinforcement and verbal remediation on the rate, accuracy, and length of sentence composition by deaf children.

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THE EFFECTS OF TOKEN REINFORCEMENT AND VERBAL REMEDIATION ON THE RATE, ACCURACY, AND LENGTH OF SENTENCE COMPOSITION BY DEAF CHILDREN

A Dissertation Presented

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ABSTRACT

An experiment was conducted in which the effects of token reinforcement and verbal remediation on the rate, accuracy, and length of sentences written by ten deaf children were assessed. The subjects were fourth grade students in a residential school for the deaf. A total of 41 experimental sessions, 50 minutes long, were run in which subjects wrote sentences. There were six experimental phases: Baseline, Reinforcement, Reinforcement plus Remediation, No Consequation, Reinforcement plus Remediation, and Reinforcement plus Remediation for Higher-Order Sentence Writing. A token economy was established through the use of points to consequate the writing of grammatically correct sentences by the subjects. Points could be exchanged for various items by subjects. Subjects worked in the Mediated Interaction Visual Response System during the sessions. This system provides each subject with an overhead projector so that his writing is directly visible to facilitate immediate consequation. The results of the experiment demonstrate that effective control was established over the behavior of the subjects. The instatement of reinforcement and remediation as consequences for appropriate composition established and maintained high response rates and high levels of accuracy. Reversal of the effects was obtained through withdrawal of the consequences and later reinstatement. Modification of contingencies requiring more complex behavior resulted in a more frequent occurrence of higher-order sentence writing.

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SECTION I

INTRODUCTION

The purpose of this investigation is to analyze the effects of a teaching methodology on a complex type of verbal behavior in deaf children. The teaching methodology developed in the experiment is based on certain principles of behavior; token economy, contingency management, and teacher-student interaction. The technology employed is based on recent developments in educational media. The verbal behavior of deaf children analyzed in the investigation is sentence-writing. Various aspects of the problem require explication beginning with the technical features of an operant analysis of human verbal behavior and particularly the application of operant technology to classroom management.

The Modification of Verbal Behavior. The experimental analysis of verbal behavior has been limited by the range of variables manipulable in controlled experiments. One of the most serious limitations has been that in research dealing with verbal behavior, subjects did not compose long responses. The use of programmed materials in educational settings is the most widespread application of behavioral technology in that field. In the various forms of programmed instruction a necessary feature is that subjects respond to frames actively. These active responses take the form of single word, single phrase, single item choice, or manipulandum operation in most cases. Even in more sophisticated forms of computer assisted instruction (CAI) presently being developed (Atkinson and Wilson, 1968) the range of vocabulary and forms of responses available to

subjects are severely limited. In programmed instruction of all types, the behavior reinforced and maintained by the operations of the program is the production of content by an individual. The concern of this study is the analysis of the production by students of grammatically correct sentences. The process of composing verbal behavior which is based on the sampling of available content by an individual has not been submitted to empirical analysis. That is, subjects progressing through programmed material actively respond by producing content. Reinforcement of behavior is contingent upon the occurrence of a match between a response and a pre-determined correct answer. Reinforcement throughout programmed learning is not contingent on the manner in which language is composed.

Composition[1], or writing as a complex form of verbal behavior, has been extensively treated by Skinner (1957). The process of composition is described as one in which an individual ". . . not only emits verbal responses appropriate to a situation or to his own condition, he clarifies, arranges, and manipulates this behavior. His activity is autoclitic because it depends upon a supply of verbal responses already available (p. 344)." "The term 'autoclitic' is intended to suggest behavior which is based upon or depends upon other verbal behavior (p. 315)." Verbal behavior which involves the use of autoclitics to produce certain effects in the listener is behavior composed by the speaker. Such verbal

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[1] "Composition" is used here as a technical term which includes activities involved in several forms of verbal behavior including writing, speaking, and certain types of non-oral social behaviors.

behavior is prescribed by the community in which it occurs. Standard conversational English requires a certain level of autoclitic activity to occur before the speaker is judged by the community as being correct, proper, or sophisticated in his language usage. Skinner's treatment of composition deals mainly with the functioning of language at a high level of literary sophistication and does not deal with the acquisition of composed language at an early stage.

In another discussion of writing, Skinner (1954) deals with the suitability of an instructor in developing effective composition by students. He states that the technology of teaching (programming) serves the purpose of freeing the instructor for accomplishing those complex tasks for which technology is not suited. One of these tasks for which the instructor is suited most ably is in guiding students' growth in the composition of complex forms of verbal behavior, i.e. sentence writing, story composition, poetry, etc. In order for an instructor to assist his students in the growth of the capability to compose verbal behavior or write sentences, the technology of teaching should generate a level of autoclitic activity and provide a supply of verbal responses which equip the student to engage in composition.

Contingency Management. The implied separation of technology and instruction by a human which is contained in the preceeding discussion is only for convenience. Recently there have been developed a number of techniques for use by classroom teachers to modify complex behaviors of students. These are the techniques of contingency management described by Michael (1968a). The techniques are adaptations of principles of behavior developed through the

experimental analysis of behavior in the laboratory and through the growth of edueational teehnology and programming. The principles have been put to use in naturalistic elassroom settings so that the instructor may efficiently manage students' behavior (Ayllon and Azrin, 1965; Miehael, 1968a; Ulrich, 1968a).

The adaptation of reinforcement teehniques to classroom management is of partieular interest. Miehael (1968a) points out that teachers neecssarily must tabulate the occurrenee of desired behaviors by students in order to determine whether eonsequenees of that behavior mediated by the teaeher do in fact aet as reinforcers. Seeondly, teaehers neeessarily must identify elearly the behavior being eonsequated. For example, if a child engages in disruptive activity in the classroom and the consequenee of that behavior is attention from the teacher, the behavior may inerease in frequency. If the teacher had effectively managed the contingency the disruptive behavior would dccrease in frequency. That is, attention from the teaeher would only be given to this particular student following the occurrence of desirable behavior on the part of that student.

Consequation of behavior by teaehers must also be immediate for maximum effectiveness. A eommon praetice in classrooms when students are asked to write compositions or to take examinations is for them to submit their papers to the teaeher who then takes the papers away from the school, eorrcets them, and hands them back on the following day or thereafter. The eontingencies associated with test taking or eomposition then may not be clear to the student. Errors committed are not immediately identified. The contingeney between composition writing and test taking behavior and a letter grade or seore on a

paper is so far separated in time as to be often non-effective. In a discussion and review of reinforcement procedures in human training, Wolfle points out that

> "The subject should be told his results not only as precisely as possible, but also as soon after each trial as possible. This principle applies to both animals and men . . . in typical learning situations the relation between length of delay and effectiveness is described by an exponential or negative growth function . . . The knowledge of results . . . should be automatic, immediate, and meaningfully related to the task being learned."
>
> (Wolfle, 1951, pp. 1268-1269)

Another contingency management technique available to teachers is called remediation. As in the illustration above, a student taking an examination and a day later receiving his paper with a mark on it is not directed to information relevant to prompting a correct response if the same series of questions is repeated. Keller (1968) has described the process of programming classroom instruction which describes the steps necessary to effectively remediate inappropriate responding on the part of students. Inaccurate responses from students can be followed by the information necessary to make their responses accurate. This is particularly true of more complex forms of verbal behavior such as sentences and short paragraphs.

Token Economy. The literature in the area of applied behavior analysis in recent years has contained many reports of techniques and procedures for

adapting principles of behavior to increase the quality of instruction or therapy for children with a variety of handicaps and deficits both physical and intellectual. One technical strategy which has been taken from the experimental laboratory to the field is that of using a token system of reinforcement to control and maintain behavior (Ayllon and Azrin, 1965; Birnbrauer, Wolf, Kidder, and Tague, 1965; Green, Sanders, and Squier, 1959; Hefferline and Keenan, 1963; Lane, 1964; Weiner, 1962, 1963, 1964a, 1964b, 1964c, 1964d, 1969).

The events which are available to teachers as consequences for student behavior in many situations may not be effective in controlling behavior. The common teacher behaviors used as consequences (such as praise, attention, and approval) may not operate in sufficient strength to modify or maintain desirable rates of responding on the part of students. In such cases, a token economy (the use of secondary reinforcers, e.g., marks on paper, points on a counter, poker chips, or money, which are at a later time used by students to trade for desired objects) may be used to produce the kinds of behavior changes desirable in some educational settings. In another typical setting, Ayllon and Michael (1959) and Ayllon and Azrin (1965) have produced significant changes in the behavior of patients in mental institutions through the use of effectively managed contingencies reinforced by tokens.

The use of token reinforcement has other advantages in an educational setting. Individuals working for tokens may exchange them for their selection from a "menu" of reinforcers, all of which have been identified as salient by the individuals themselves. This feature of the use of token reinforcement

economies overcomes the difficulty faced by many teachers when they incorrectly identify the consequences for behavior. For example, teachers may be surprized to find a student who ceases to engage in desirable activity following attention and praise from the teacher. The effect of the attention and praise is the reverse of that expected by the teacher. Since he has experienced past success in maintaining students' behavior by offering praise and attention as an outcome, the teacher may persist in offering such consequences. Productive behavior in the individual case may be disrupted or extinguished. Establishing a token economy would overcome this difficulty.

In those cases where teacher approval is used as a consequence in educational settings, those students for whom the effect of such a consequence of behavior is neutral or negative are at a distinct disadvantage in the classroom. Token economies can be utilized to increase the salience of teacher approval for such students. Teacher attention, approval, and praise can be paired with the delivery of tokens thereby establishing a neutral stimulus--positive reinforcer relationship in which the neutral stimulus gains strength as a secondary reinforcer. Lovaas (1969) has employed this technique in teaching language to psychotic children who displayed fear and withdrawal at the occurrence of attention and contact from others. By pairing approval with the presentation of food reinforcers and then carefully fading the primary reinforcer of food, attention and approval gained strength which was sufficient to shape and maintain verbal behavior on the part of these particularly difficult subjects.

Ulrich (1968b) points out that systems of token reinforcement provide a

degree of objective measurement for behavior change which is ordinarily not available to teachers. An individual student's progress relative to whatever criteria are established in the classroom can be recorded quite simply on the basis of the number of tokens earned during a given period of time. With such a highly explicit record of individual progress teachers could provide more extensive individualized instruction than is possible without such a record.

Some Philosophic Considerations. Since the beginnings of behaviorism as a distinctly labeled approach in modern psychology (Watson, 1913) until the present developments of operant technology in clinical and educational settings (cf. Skinner, 1968), theoretical and philosophical arguments have been stated to counter the view of man and the utilization of scientific technology in man's affairs. The arguments against radical behaviorism are represented in the debate between Skinner and Carl Rogers (1956) and in the recent symposium concerning behaviorism and phenomenology (Wann, 1964). Current summary interpretations of the conflict between behaviorists and humanists or phenomenologists are available (Day, 1969; Hitt, 1969).

An extended discussion of the characteristics of radical behaviorism and phenomenology is not relevant here. However, some of the issues which operate in naturalistic settings such as classrooms to generate antipathy toward the operations of behavioral technology are of interest. One of the principal objections raised to the utilization of scientific principles in schools is that those procedures and techniques are based on the development of control over students. The word "control" carries such a large number of connotations (generally

related to the activities of tyrants and despots) that the technical use of the term is lost. All of us control and are controlled by the behavior of others. When that control is planned, particularly in dealing with children, strong emotion is reflected in the verbal responses of critics in whose responses the words "free," "freedom," "worth," and "dignity" occur with great frequency. Skinner (1955) is fully aware of the dangers inherent in a powerful means for the control of human affairs and suggests means for insuring protection of man's freedom, worth and dignity through ethical counter-control. The history of man's errors in his treatment of his fellows is devastating. Processes operating in cultural evolution have improved the human condition very slowly. Now that the application of effective scientific methods to human behavior has begun, critics (Krutch, 1953; Negley and Patrick, 1952) object to the fact that planned change in societies' institutions is probable. The flavor of Skinner's objectives for man can be seen in his discussion of criticisms of his utopian novel Walden Two:

> "One would scarcely guess that the . . .(critics). . . are talking about a world in which there is food, clothing, and shelter for all, where everyone chooses his own work and works on the average only four hours a day, where music and the arts flourish, where personal relationships develop under the most favorable circumstances, where education prepares every child for the social and intellectual life which lies before him, where--in short--people are truly happy, secure, productive, creative, and forward-looking. What is wrong with it? Only one thing: someone

'planned it that way.' If these critics had come upon a society in some remote corner of the world which boasted similar advantages, they would undoubtedly have hailed it as providing a pattern we all might well follow--provided that it was clearly the result of a natural process of cultural evolution. Any evidence that intelligence had been used in arriving at this version of the good life would, in their eyes, be a serious flaw." (Skinner, 1961, p. 31)

Another form of criticism leveled at the operation of a behavioral technology in schools is that any learning which takes place without effort, deprivation, sacrifice, or strain is given less credit or admiration than that learning which takes place with such attributes. For example, Abraham Lincoln is admired more for his education than is Franklin Roosevelt because more personal effort and striving was required for Lincoln to acquire knowledge and wisdom. Roosevelt acquired the benefits of the "best" schools and colleges easily due to his family's wealth and position. No matter that both men were well-educated, one had to work harder to become so than the other and is therefore somehow better because of that chance of birth.

"By admiring the student for knowledge and blaming him for ignorance, we escape some of the responsibility of teaching him. We resist any analysis of the educational process which threatens the notion of inner wisdom or questions the contention that the fault of ignorance lies with the student. More powerful techniques which bring about the same changes in behavior by manipulating external

variables are decried as brainwashing or thought control. We are quite unprepared to judge effective educational measures. As long as only a few pupils learn much of what is taught, we do not worry about uniformity or regimentation. We do not fear the feeble technique; but we should view with dismay a system under which every student learned everything listed in a syllabus--although such a condition is far from unthinkable. Similarly, we do not fear a system which is so defective that the student must work for an education; but we are loath to give credit for anything learned without effort--although this could well be taken as an ideal result--and we flatly refuse to give credit if the student already knows what a school teaches." (Skinner, 1961, p. 29)

By utilizing features of the technology available for the modification of verbal behavior in the classroom, the teacher

". . . clarifies the variables . . .(he). . . is manipulating, as well as their effects. A technology of teaching improves the role of the teacher as a human being. It provides capital equipment which gives him some of the time he needs to be human. It frees him from the need to maintain aversive control or to motivate his students in spurious ways . . . A technology of teaching also permits a teacher to teach more than he knows . . . In the long run a technology of teaching helps most by increasing the teacher's productivity. It simply permits him to teach more--more of a given

> subject, in more subjects, and to more students . . . being more productive does not mean working harder. On the contrary, it means working under better conditions and for a more appropriate return . . . A technology of teaching by its very nature maximizes the teacher's achievement." (Skinner, 1968, pp. 256-258)

A teacher provided the greater availability of time offered by a technology for classroom management can engage in the instruction of students in such areas as writing and social behavior. Without an effective technology, little time is available for teachers to devote to the process of composition or writing and attention is then focused on the production of content-specific behaviors by students. The development of procedures for teachers to provide instruction in complex verbal activities (specifically autoclitic activity) is one important aspect of the maximization of the teacher's achievement.

The Verbal Behavior of Deaf Children. An area of application for behavior modification techniques (such as contingency management procedures and token economies) which has not been explored to any extent is language instruction for deaf children. As a group, the deaf have a clearly defined subculture. This is particularly true when considering the growth of educational institutions, curricula, and methods of instruction since the establishment of the first school for the deaf in 1817. The American School for the Deaf in Hartford, Connecticut was established through the efforts of Thomas H. Gallaudet who received training in manual methods of instruction for the deaf in France at the first public school for the deaf in Paris. Throughout the history of education for the deaf the focal

objective in schools has been to produce individuals capable of functioning in a hearing world.

Historically, educators of the deaf have been in conflict over the methods most appropriate for instructing deaf children. Silverman (1964) describes the origins of the differences between advocates of the "oral" and the "manual" approaches to instruction as originating about 1775 between Abbe Charles Michel de l'Epee and Samuel Heinicke.

> "De l'Epee and Heinicke disagreed about the merits of (manual) signs and 'oralism' as methods of instruction, de l'Epee favoring signs and Heinicke writing prolifically on the advantages of speech and of speechreading. So widespread was the influence of these two men that the pattern of their controversy was reproduced subsequently in many countries, the United States included."
>
> (Silverman, 1964, p. 408)

The conflict between advocates of the two techniques continues today. With the increased amounts of information available on the nature and extent of individual differences since the early decades of the twentieth century, a concomitant growth of concern for individual student capabilities has modified the extent of differences between the two types of instruction. Myklebust (1964) favors the development of speechreading in deaf children as a more adequate form of language than manual communication, but notes that individual capabilities of students should arbitrate the use of instructional methods rather than theoretical or administrative dispute.

The term Aptitude-Treatment Interaction was used by Cronbach (1968) to characterize an approach to the empirical solution of educational problems such as the one described above. The aptitude-treatment interaction approach involves assessing the individual characteristics of students and matching those educational curriculums and techniques which have the highest probability of being effective with that individual. The approach involves more than placing students who obtain high scores on intelligence or reading tests in "accelerated" classes. Suggested in the approach is a detailed examination of the extent to which a student's aptitudes and capabilities can be matched with a particular pattern of instructional techniques and materials.

Regardless of the form of communication taught to deaf students, or the possibility of introducing research in deaf education based on the aptitude-treatment interaction model, the academic achievement of high school graduates from schools for the deaf is less than would be anticipated from the number of years spent in school (Fusfeld, 1955). After approximately 13 years of schooling, two sizeable groups of deaf high school graduates applying for admission to Gallaudet College (the only four-year college exclusively for deaf students) were tested using the advanced battery of the Stanford Achievement Test. This select group of students achieved grade equivalency scores overall which were three years less than their chronological academic age ($\bar{X} = 10.2$, $n = 134$ and $\bar{X} = 9.9$, $n = 146$; standard deviations are not reported by Fusfeld). The subtest achievement levels of this group of deaf students is revealing. On tests of students' abilities in language forms and structures, i.e. punctuation, and grammar,

obtained scores were high ($\overline{X}$ = 11.6, n = 134 and $\overline{X}$ = 11.9, n = 146). However, the same two groups scored much lower on two subtests of non-mechanical aspects of language ability, paragraph meaning ($\overline{X}$ = 8.2, n = 134 and $\overline{X}$ = 6.7, n = 146) and word meaning ($\overline{X}$ = 7.4, n = 134 and $\overline{X}$ = 6.4, n = 146).

Language teaching in schools for the deaf is typically patterned to a great extent and relies on drilled recognition of formal aspects of language. However, the written discourse and vocabulary of students is poorly developed. Most special techniques of non-oral language instruction for the deaf require that a student learn a symbol system different from and in addition to the symbol system represented in the English language itself.

Such symbol systems concentrate on formal grammar. Three of the most popular systems of language instruction for the deaf and the year in which they were developed are: (1) The Barry Five-Slate System, 1899; (2) Wing's Symbols, 1883; and (3) The Fitzgerald Key, 1926. Each of the systems employs written symbols to represent grammatical relationships among words in a sentence and a placement system for word order in sentence and question structure. A method of language instruction which does not employ an additional system has been recently developed (Groht, 1958) and is being used in some schools on a small scale. It is questionable whether continued use and further development of teaching methodologies for language which rely on students' learning an additional symbol system will be able to produce any noticeable changes in language competence among deaf students. Aside from the categorization system and general notation system used in English grammar the educational necessity

for other methods of abstract symbolization for teaching language is not clear. A similar issue is discussed by Chall (1967) in treating the development and utilization of a teaching alphabet of over 40 characters.

Furth (1966) estimates that only four percent of the deaf individuals in this country perform at a superior level in both receptive and expressive language behavior. This is in spite of the fact that a deaf child may enter a residential school for the deaf between the ages of two and three and receive almost daily instruction, practice and drill in speaking, speechreading, reading, and writing for the next 16 to 18 years. In a recent assessment of language competence in deaf children (Wrightstone, Aronow, and Moscowitz, 1962) deaf children in the age range 15 to 16 ($n = 1075$) were tested using the Reading Test of the Metropolitan Achievement Tests Elementary Battery. The mean grade equivalent was only 3.5 (mean raw score and standard deviation were $\overline{X} = 21.6$, $sd = 9.5$) and only 12% of those tested achieved at a grade equivalent of 4.9 or above.

To provide illustrations of the limited abilities of deaf students to compose language, samples of student compositions were obtained from fourth, sixth, and twelfth grade classes at a residential school for the deaf (The American School for the Deaf, Hartford, Connecticut). Because the sentence is the smallest unit of written language which requires composition and can be analyzed in terms of quality, the examples listed are of that form. Also, research on the language usage of deaf children has used the sentence as the unit of analysis (McCarthy, 1954).

Here are four sentences written by fourth graders following extensive discussion of verbal and pictorial presentations of a story sequence:

1. So a bee scamper him and he ran into the house was he cry.
2. My father went store and bought sprange fly.
3. The dog ran away and hid to the bedroom.
4. After that the bee went the beehive and following that bee.

The second series of four sentences is from students in the sixth grade:

1. The water is lake in Vermont.
2. My dog is very, very, very happy the snow was going down but he was played with the snow.
3. Mike S. was happy the Santa Claus gave Mike a toys on Decembe 24, 1964.
4. (In referring to a visit to the circus) I saw a man was fat and man was thin I saw a dwarf and clown.

Here are another four sentences from high school seniors labeled as high achievers and who plan to enroll in Gallaudet College:

1. Yesterday afternoon Mrs. G. took class to the offset department to see how understand about the offset machine work.
2. I was more interestly this.
3. So in a few minute Mr. D. explained about how to run machine, how to use the right exact of water, ink, and paper.
4. While we coming back here I tease Mrs. G. for bein an old cute little lady.

From these examples, little change in accuracy of sentence composition occurs over a period of time spanning eight years of school. The types of errors in the twelve examples are fairly consistent in both density and form. That is, the number of errors per sentence and the types of errors committed are similar. The examples are drawn from compositions by approximately 50 students at the three grade levels.

Myklebust (1964, pp. 273-348) points out that deaf students plateau in their language ability between the ages of 9 and 15 with only relatively minor improvement in expressive language from age 15 to age 17. One possible account for the apparent slow rate of improvement in composition accuracy after the fourth or fifth grade can be seen in an examination of a language arts curriculum for a school for the deaf. One such curriculum guide (Curtis, 1967) provides objectives and suggested methods of instruction for deaf children in residence from the age of three to the senior year of high school. In every segment of the curriculum guide, directions are provided for a considerable expenditure of instructional time in formal acquisition of vocabulary through drill, language usage, rules of grammar, and spelling. Time is also to be spent in what is labeled original language, i.e. composition or writing. At the early stages of language instruction, the steps in any given segment of the curriculum guide are broken into fairly small discrete elements. As the guide progresses to higher grades, these segments become larger. Ultimately at some point in the primary grades, the elements in language arts instruction become so large that contingencies of reinforcement become less explicit and consequences of students' verbal behavior

become separated in time from that behavior. Another feature leading to this growing lack of direct consequation in instruction is that in the administrative procedures utilized in the school under discussion, period-based rotation of students from teacher to teacher begins at the fifth grade. In terms of an analysis of behavior, therefore, as the grade level increases, teachers more frequently resort to requiring a written product from students, but are less able to remediate or to directly consequate the behaviors of writing as they occur. A contingency of reinforcement may be established in the classroom in which teachers administer approval, attention, and praise (or withold disapproval and punishment) to consequate writing on paper rather than to consequate writing accurately.

Design Considerations. The design of the experiment is more similar to the single subject, multiple manipulation, multiple replication than it is to the multiple subject, single manipulation, single replication type. The behavioral phenomenon under investigation (manipulation of composed sentence writing behavior) cannot be effectively investigated through the latter type of design. The measures of behavior change which were used in the experiment as dependent variables are rate, accuracy, and length of sentence writing behavior.

Sidman (1961) draws attention to the requirements for designs and procedures in experimental psychology in which

> "the consistency of the individual curves in the face of the individual differences in rate serves to extend the reliability and generality. Every demonstration that a behavioral phenomenon is independent

of variables that one has reason to suspect would be important factors serves to extend the generality and reliability of that phenomenon. The significance that will be assigned to such a demonstration is not basically a statistical matter."

(Sidman, 1960, p. 83)

Because of the type of design used in this experiment, statistical procedures common to the interval estimation and hypothesis testing models of experimental design are not appropriate. The criterion for effectiveness of the manipulations performed in the experiment will be determined on the basis of attainment of steady states in the behavioral phenomena under investigation. Sidman (1961, p. 237ff) distinguishes between two types of experimental interest in steady state behavior. These are descriptive and manipulative. The descriptive type of study which is now common in the experimental laboratory, deals mainly with behavior in infra human species, as characterized by the work of Ferster and Skinner (1957) on schedules of reinforcement. In the descriptive type of design, the independent variables are fixed over a large number of experimental sessions and the experimenter focuses his attention on transition and steady states in the behavior measured. In manipulative studies of behavior change and steady state, the technique of reversibility of behavior change is utilized. Reversibility of behavior change can be accomplished in one of two ways. (1) Systematic replication of behavioral phenomena calls for the manipulation of the levels of the independent variable with more than one subject in different orders. (2) Direct replications of manipulative behavior phenomena

utilize single subjects undergoing a series of independent variable manipulations in which steady state behavior undergoes a process of reversal through transition until another steady state is obtained. Of principal concern in a design in which direct replication of independent variable manipulation occurs is the establishment of stability criteria.

There are a wide variety of stability criteria possible in the experimental analysis of behavior which are concerned with causing variability in behavior to conform to a pattern. For this reason, "stability criteria can neither be selected blindly nor slavishly adhered to (Sidman, 1961, p. 271)." The selection of a stability criterion for each of the dependent variable measures employed in this investigation will itself be a systematic process. The first sort of stability criterion to be used in the investigation will be visual inspection for stability in the data. The use of stability criteria based on simple visual inspection of data has a history of widespread use in the analysis of operant behavior beginning with Skinner (1938).

Experimental Objectives. A teaching methodology was developed to provide deaf children with an environment in which events occurred that were directly relevant to decreasing their limitations in writing sentences. The methodology was directed at increasing the frequency of occurrence of grammatically correct sentence writing behavior of subjects and, thus, improvement of the extent to which deaf students use accurate language. The methodology allowed direct consequation of writing to occur and also permitted direct interaction between the teacher and student for the remediation of inadequate writing.

SECTION II

METHOD

Subjects. The American School for the Deaf was chosen as the site for experimentation. Initial discussions of the research and the procedures to be followed were held with administrative officers of the school. The portion of the student body (approximately 150 students) in the first, second, third, and fourth grades at the American School are housed in one building and do not rotate classrooms or teachers during the teaching day. The students in one fourth grade class were selected for use as subjects in this experiment. Ten children between the ages of 10 and 13 comprised the class. The subjects as a group present a variety of background profiles (see Table 1). Three subjects were day students and 7 were residential students. Four subjects have deaf parents and six have hearing parents. Six or possibly seven subjects are congenitally deaf (records from the school regarding one subject were incomplete).

The experimenter has had no specialized training for working with deaf children and for this reason he spent several days working in conjunction with the regular classroom teacher to adapt himself to the students in the class and to permit the students to become familiar with the experimenter's manner of speaking and presence in the classroom and the school.

Individual audiographic data summaries for the subjects are presented in Table 2. Hearing loss is expressed in sound pressure, measured in decibels, required for a subject to just discriminate that sound from silence. In order

TABLE I

Background Data on Subjects

Name	Age	Age at Onset of Deafness	Date of Admission	Previous Schooling	Deaf Parents or Hearing Parents	Siblings
Barbara (R)*	11- 6	Birth	11 Sep 62	None	Deaf Parents	1 (deaf)
David (R)	10- 8	Two Years	27 Feb 67	3-1/2 Yrs	Hearing Parents	5
Denise (R)	11- 1	?	12 Sep 61	None	Deaf Parents	2 (deaf)
Lorna (R)	10-10	Birth	14 Jan 62	None	Deaf Parents	None
Maurice (R)	11- 5	Birth	27 Mar 61	None	Hearing Parents	2
Peter (D)	11- 3	Birth	12 Oct 61	None	Hearing Parents	4
Richard (R)	11- 4	Birth	18 Sep 61	1 Yr	Deaf Parents	3 (deaf)
Scott (D)	13- 2	Two Years	10 Sep 63	1 Yr	Hearing Parents	4
Steven (D)	10- 9	18 Months	12 Sep 61	None	Hearing Parents	2 (1 deaf)
Susan (R)	12- 6	Birth	11 Sep 63	None	Hearing Parents	3

*(R) denotes Resident Student (D) denotes Day Student

TABLE 2

Hearing Loss Summaries for Subjects in Decibels

	Hertz						
Subject	125	200	500	1000	2000	4000	8000
Barbara	35/40*	35/40	50/60	50/60	60/60	50/55	35/40
David	65/55	70/45	95/50	95/90	--/--**	--/--	--/--
Denise	50/65	60/60	80/75	100/95	--/100	--/--	--/--
Lorna	55/40	60/40	60/50	70/60	75/65	65/60	45/55
Maurice	60/30	75/35	90/45	100/55	--/70	--/75	--/65
Peter	65/--	65/70	90/90	95/100	100/--	--/90	--/--
Richard	60/50	70/65	85/95	100/--	--/--	--/--	--/--
Scott	60/15	65/15	95/45	--/50	--/55	--/85	--/65
Steven	70/65	80/80	90/90	100/95	--/95	--/95	--/80
Susan	45/35	50/40	75/55	80/70	75/65	70/60	50/35

* The first number in each cell is the db loss for the right ear and the second number is the db loss for the left

** -- denotes no response

to establish convenient units of measurement for testing what is an individually determined variable (absolute threshold), the American Standards Association has established arbitrary parametric values for decibel measures (Licklider, 1951, pp. 994-996). The minimum audible field for 1000 herz is taken as 0.0002 dynes per centimeter squared or 0 decibels. Because of the relationship between power and pressure, a tenfold decrease in power is expressed as -20 decibels. The selection of the parametric value given above is not quite arbitrary, but is rather based on audiological data from subjects in their early twenties with no discernible hearing disability. To read Table 2, follow the figures in one row across columns. Hearing loss at a given sound frequency for the right ear is given as the first number and hearing loss at that frequency for the left ear is the second number. The absence of a number indicates that the subject did not respond at that frequency regardless of the amplitude of the sound presented.

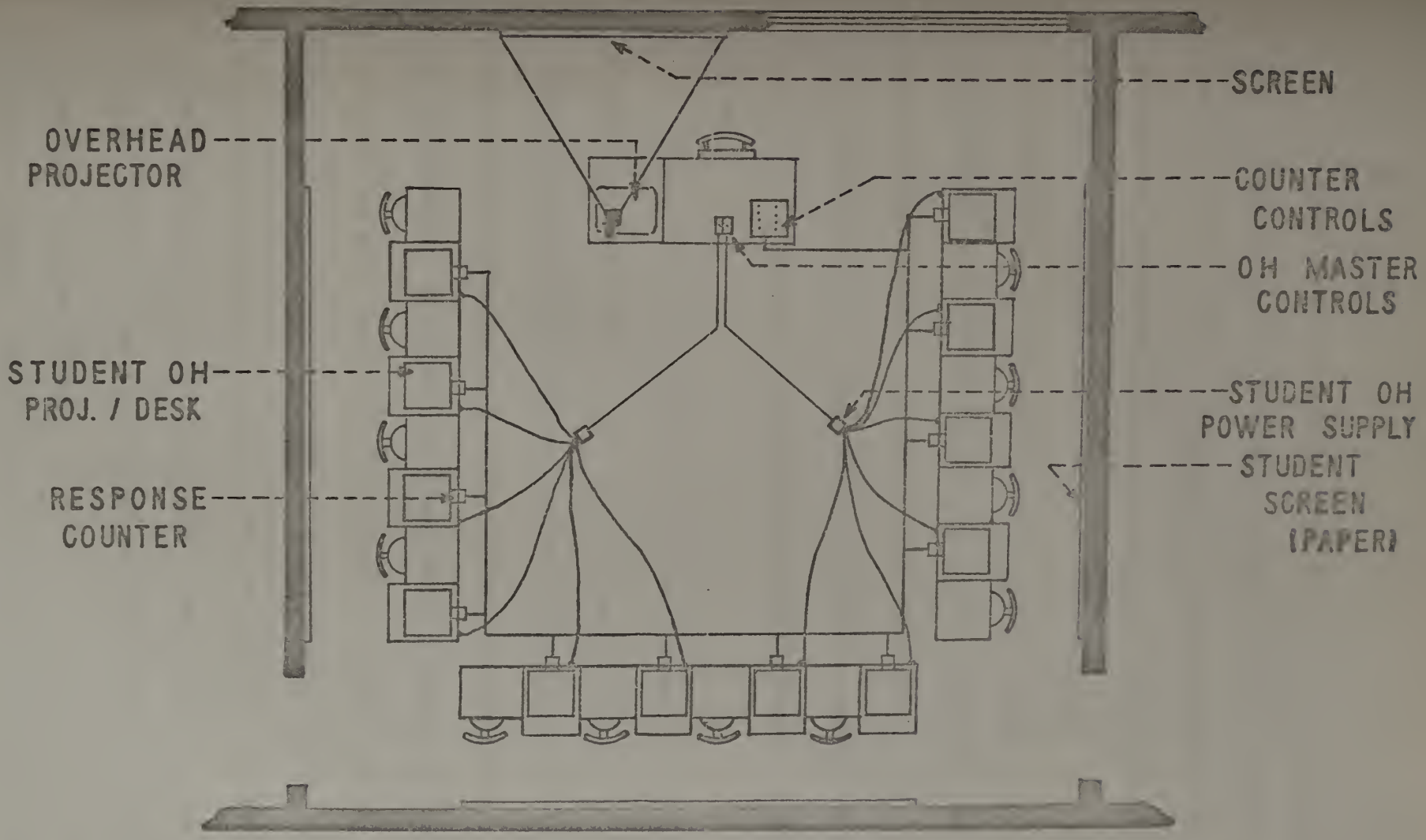
Equipment. The Mediated Interaction Visual Response (MIVR) system developed by Wyman (1968) makes possible in small group instructional settings many of the features of programmed instruction. At the same time it incorporates desirable aspects of direct interpersonal interaction in the teaching process. The system consists of a set of overhead projectors for use by a class of students and one teacher. The MIVR provides individual students with immediate visual feedback for active responses to educational material. Pacing in instruction is not individual, but remediation of inappropriate responses can be accomplished by direct participation of the teacher and/or the other students.

The most interesting feature of the MIVR (in comparison to the basal requirements for a programming device) is that since the teacher is present, composed pupil responses can be immediately evaluated by a teacher.

> "The primary purpose of the visual response system is to provide several students with individual but simultaneous visual feedback devices to their teacher in place of or in addition to the usual one-at-a-time oral response. Individual oral response certainly has an important place in education but it is not the primary concern of MIVR system." (Wyman, 1968, p. 1)

The MIVR system was developed in late 1967. Since that time it has been installed in various schools of the deaf. Anecdotal evidence from teachers who have used the system indicates that the opportunity for more direct and immediate consequation of responses from students is a highly desirable feature. In addition, the system by its very nature requires that teachers prepare instructional materials in a form calling for relatively high frequencies of responses from students and that teachers present information in manageable amounts.

In the procedure to be followed in the experiment a modification of the MIVR system was necessary. The procedure described below describes a token reinforcement system for subjects. Points were used as token reinforcers. In order to make visible to each subject his cumulative point total during each experimental session, a system of counters was added to the MIVR. These counters could be advanced through a system of switches at the instructor's console (see Illus. 1).



MEDIATED INTERACTION VISUAL RESPONSE SYSTEMS
WITH RESPONSE COUNTERS

The determination of the reinforcers to be available by exchanging points was accomplished by simply asking the subjects what toys and games and activities they enjoy playing with or engaging in. A list was compiled of the items and activities and a stock of items was purchased. An array of items was available to the subjects at the end of each experimental session. The games and toys named by the subjects covered a broad range of expense from balloons to such things as costly dolls and roller skates. The actual items used as reinforcers are listed in Table 3. In addition to the items used as reinforcers, points were used to exchange for admission to lunchtime presentations of cartoons. The point value range to obtain the various items provided as reinforcers was 1-499.

The stimulus materials to be used in the experiment are a subset of overhead projector transparencies drawn from a language arts series of transparencies for teaching hearing impaired children (Wyman and Tilley, 1968). These transparencies were developed as aides in the teaching of elementary language to deaf children. They were specifically designed to deal with language principles or forms and to assist in the development of original language composition. The transparencies used all contain pictures of objects, people, and places. Some show relationships of function, form, or material. Two hundred transparencies comprised the set. Many single transparencies contain multiple images. That is, a given transparency could contain 2, 4, 5, 6, 8, or 10 images which could be presented singly or in groups to constitute a single stimulus event for sentence writing. Transparencies were presented in random order. When

TABLE III

Toys, Items and Games Chosen by Subjects as Salient Reinforcers

Roller Skates	Fishing Equipment
Dolls	Mirrors
Croquet	Toy Horses
Checkers	Spirograph
Baseball	Kerplunk (game)
Football	Kites
Comic Books	Balls
Cook Stove	Model Cars
Toy Mixer	Jigsaw Puzzles
Twister (game)	Barbie Doll
Mousetrap (game)	Balloons
Bingo	Guns
Cat & Mouse (game)	Comb & Brush Sets
Story Books	Dinosaur Models
Hats Off (game)	Paint & Brushes
45 rpm Records	Admission to Cartoons

the full set had been presented, the transparencies were reordered and their presentation was repeated.

The MIVR system was housed in a small classroom within the building normally used for primary grade instruction at the American School. When not in use for experimental purposes the room and the equipment were used by other teachers of primary grades in the school.

Procedure. The three dependent variable measures used were of different types. The rate of sentence writing behavior, i.e. the number of sentences written per session, was determined by the group of ten subjects as a whole. Rate of response was plotted as a frequency distribution over time in terms of the number of sentences written during each session. The fact that subjects did not work at an individual pace introduces the possibility of certain variables operating in addition to those directly manipulated to produce changes in sentence writing behavior. The second dependent variable measure, accuracy of sentence writing (as judged by the experimenter), is an individual measure from which data were obtained from the ten subjects. Data were plotted on a daily basis throughout the series of experimental sessions in terms of the number of correct sentences expressed as a percentage of the total number of sentences written during a session. The third dependent variable measure, number of words per sentence was determined by plotting word counts for each sentence written by each subject during a session. The variable measure was then expressed as a mean number of words per sentence for each session.

The basic procedure used in the experiment was to present a series of

stimuli to subjects which set the occasion for sentence writing. Experimental sessions were 50 minutes in duration at the same time every school day over a period of weeks. Sessions began each day at 12:00 and ended at 12:50. A single writing cycle in the experimental session ran as follows: The experimenter presented a stimulus by turning on his overhead projector and displaying a picture on the screen to all subjects. Subjects then wrote a sentence on the stage of their overhead projector using a transparency acetate and writing with a wax pencil. When a subject completed a sentence he turned on his overhead projector to signal the experimenter. When the appropriate consequation of each subject's writing occurred, subjects turned off their projectors. No verbalization on the part of the experimenter or subjects was necessary; nowever, subjects were not prohibited from engaging in talking. The experimenter did not respond to direct questions from subjects regarding procedures used during the experimental sessions. Since eight sentences filled one response transparency, as many as seven were used by each subject during a given session. The transparencies were collected at the end of each session and the data of concern were tabulated from them.

The six phases of the experiment are described below:

I. Baseline. No direct consequence for sentence writing was administered in this phase. That is, subjects simply wrote sentences following each stimulus presentation.

II. Reinforcement. In this phase, a point was awarded for every accurate sentence written by a subject. Judgments of the accuracy of sentences were

made by the experimenter. The regular classroom teacher was present during each of the 41 sessions and agreed with all accuracy judgments. The presentation of a point was immediately visible to a given subject by means of a counter placed on top of the stage of his overhead projector. Point totals were cumulative. At the end of a session a small card with each subject's name and the date of the session was used to record the total number of points which was then available for later exchange. The exchange process occurred after subjects ate lunch. Points could be accumulated over a period of sessions prior to exchange for items with a point value higher than that obtained in a single session.

III. Reinforcement plus Remediation. The token system of reinforcement continued in force as in phase II. In phase III, each inaccurate sentence which occurred was consequated by the insertion of appropriate changes in the sentence by the experimenter directly on the response transparency used by the subject. On the basis of an examination of each subject's writing during the six months prior to the start of the experiment, the types of errors which occurred most frequently were determined. This determination was accomplished by reading the notebooks kept by each student of the letters written to parents each week of the school year. The types of errors judged on an a priori basis were: word omissions, use of inappropriate or mispelled words, misuse of pronouns and prepositions, tense, person, and number errors, and confusion in word order in given sentences. It was anticipated that other types of errors could occur in the experiment. Each of these types of errors in sentences was easily remediated in the manner described above.

IV. No Consequation. Reinforcement and remediation of incorrect sentence writing was terminated in this phase. This phase was an attempt to reverse the effects of the independent variable manipulations made in phases II and III.

V. Reinforcement plus Remediation. Experimental phase III was reinstated. This experimental phase was included to complete the attempted demonstration of reversal of the effects of consequation.

VI. Reinforcement plus Remediation for Higher-order Sentence Writing. A new contingency was established in this experimental phase. Since the first contingency provided reinforcement for any grammatically correct sentence, the probability of subjects' writing short simple sentences was high. In phase VI, two points were administered when a grammatically correct compound or complex sentence was written. Short, simple sentences of a fixed form (e.g., "I see a house." or "There is a dog.") were not consequated. Students at the American School receive no formal instruction on the complex and compound sentence forms until they reach the higher grades. Therefore, it was judged desirable to explore the introduction of those forms at an earlier point in the academic history of the subjects.

No particular number of sessions was chosen for the length of a given experimental phase. Judgments of when sentence writing behavior was stable in a phase and when to begin the next phase were made on the basis of a daily inspection of the data from the dependent variables. Number of sentences written per session and sentence accuracy taken together were used as the prime determiners of stability.

Instructions were presented to the subjects visually through the use of the overhead projector. Such presentations consumed time from that available in the session in which they occurred. Consequently, the number of sentences which could be written during those sessions was decreased. The first experimental session began with the presentation of the following instructions:

> "We are going to use this room for original language work. The way we will do language will be different here. Your job will be to write many single sentences each day instead of writing stories or letters. I will show you picktures of many things, one at a time. Your job is to write one complete sentence every time I show you a picture. There is a white button on the right side of your overhead projector. When you press the top of the button in, your machine will turn on. When you press the bottom of the button in, your machine will turn off. You are to turn on your projector each time you have finished writing a sentence. I will tell you to turn off the projector when I am ready to show you another picture. If your wax pencil breaks, hold it up and I will give you another."

At the beginning of experimental phase II the following instructions were presented to the subjects:

> "Tomorrow we will do something different. You will earn a point for every sentence you write correctly. At the end of the hour you may "buy" things with your points. Do <u>not</u> touch your counters--you will lose all your points. You can use the points to buy things

from the boxes I brought this morning. We will do this in Miss N's room after lunch. When you trade your points, some prizes will cost more points than you have. You may save your points until you have earned enough for the thing you want. Remember--you will get a point every time you write a correct sentence. I will give you a card when we are finished with the number of points you have earned written on it."

Following Phase II of the experiment subjects were presented with these instructions:

"Sometimes I may change a sentence you write. I will do this by marking on your sheet."

Instructions for Phase IV were:

"The counters will be gone for a while. Until they come back, I want you to work without points. I still have your points written down and you will be able to use them. Do not return to your classroom at 1:30."

No instructions were given for Phase V. A different contingency was established with the start of Phase VI with the following:

"Today we are going to change the way you get points. No points will be given if you write short statements like 'I see_____' or 'There is_____.' One point will be given for other kinds of short statements. Two points will be given for long statements that use the new words and phrases you have been taught. When you start

something new you make a few mistakes. What you are starting today is hard. Don't feel badly if you make mistakes at first. You will do better."

The experiment ran for 41 sessions beginning on 12 March 69 and ending on 16 May 69. The period during which the experiment was conducted included one school holiday and Easter vacation. Sessions were held each day the school was open.

SECTION III

RESULTS

Results will be presented in subsections treating each dependent variable; rate of response, accuracy of response, and sentence length. An additional subsection will provide information regarding the categorization of types of errors made by the subjects. In each of the 21 figures, special notations occur on six different sessions: (a) During session 10, visitors were present in the experimental room and an equipment failure occurred; (b) Subjects prompted each other for higher rate during session 11; (c) During session 14, Steven and Peter prompted Barbara for higher rate; (d) During session 15 a prompt for accuracy (Remember! Look at what you have written before you turn on your light.) was administered by the experimenter; (e) Subjects prompted each other for higher rate during session 16; (f) A sentence length prompt (Try to write longer sentences.) was administered by the experimenter during session 26. The experimenter administered prompts were given by displaying via the overhead projector a written statement of the prompt to all subjects at the start of the given session.

Rate of Response. The data on rate presented in Figure 1 are based on the number of sentences written in each session by the group of 10 subjects taken together. Appendix 1 contains the number of sentences written during each session by all subjects. On various occasions, individual subjects completed fewer sentences per session than other subjects. This was due to such events as trips

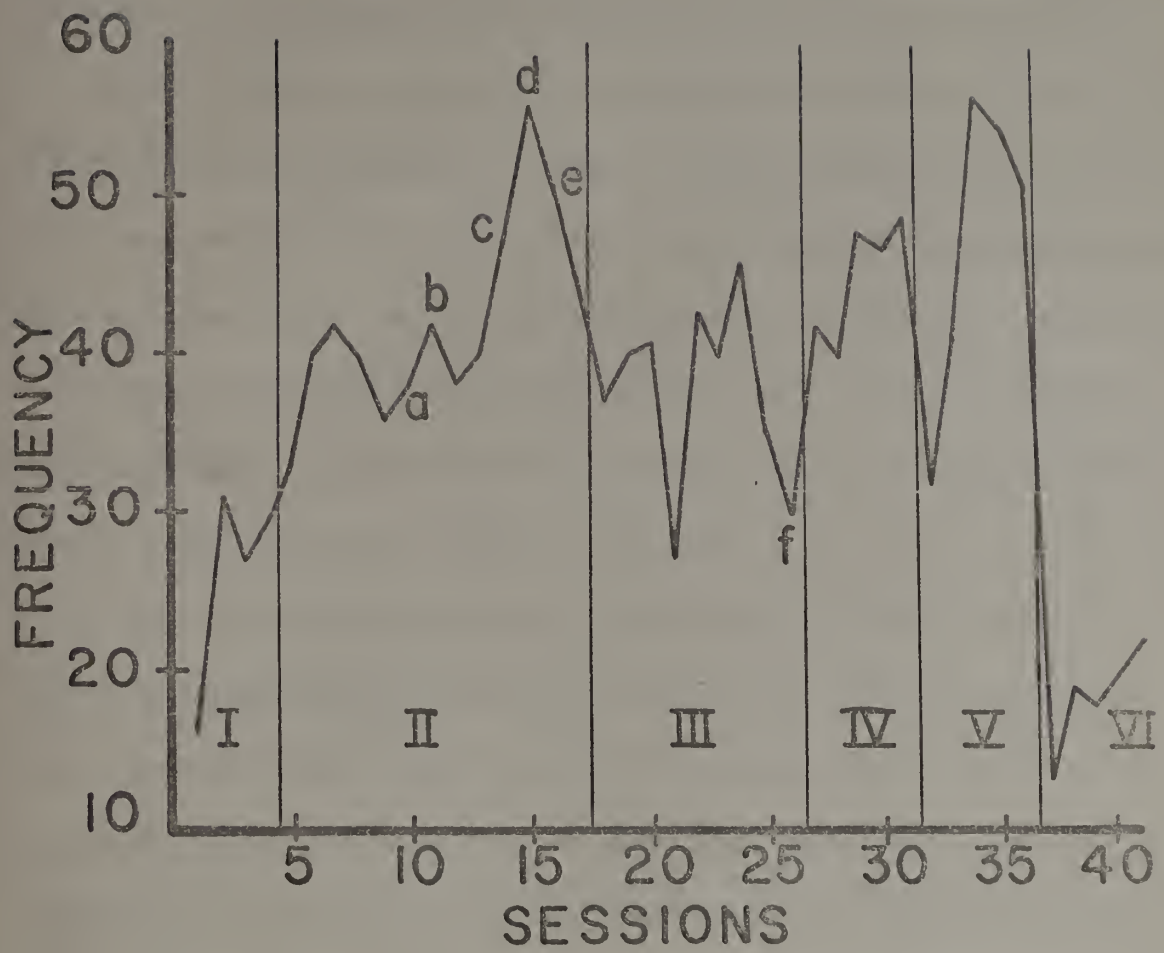


FIGURE 1 GROUP RATE OF RESPONSE (NUMBER OF SENTENCES PER SESSION)

to the infirmary for first aid or medication and parents taking children early for extended weekends. Such occurrences were random with the exception of Susan's being late or absent from the final five sessions of the experiment. She was receiving regular medication at the school infirmary on those days and could not be returned to the experimental room by the start of the session if she attended.

Phase I (Baseline) was in force for sessions 1-4. Rate stabilized quickly at approximately 28 sentences per session. Much of the time available in session 1 was consumed by the presentation of instructions and in adapting subjects to the equipment and procedure. David was absent from session 2. Denise was present for only the final 15 minutes of session 2 and completed 13 sentences. Maurice became ill during session 3 and completed only 17 sentences. Barbara, Maurice, and Richard were absent from session 4.

Phase II (Reinforcement) began with session 5 and ended with session 17. Subjects accumulated points beginning with session 5. Points were traded for items covering the full range of point costs. Barbara, Steven, Peter, and Susan expressed interest in several high cost items early in phase two. As their point totals began to approach the various amounts needed to complete the desired exchange, subjects began to prompt each other for higher rate through the end of session 16 (see points b, c, and e on Figure 1). The high point-value transactions were completed by session 16 and the earlier rapid increase in rate during the preceding 4 sessions decreased. Early in phase II, rate stabilized at approximately 40 trials per session. Rate returned to the 40-trial per session level by the end of this phase. Barbara, Maurice, and Richard were absent

from sessions 5 to 8. Peter was absent from sessions 11 and 12. Barbara left school with her mother for a long weekend holiday after only completing 12 minutes of session 13. Barbara was detained at the infirmary and completed only 38 minutes of session 16.

Phase III (Reinforcement plus Remediation) ran from session 18 to session 26. Rate during this phase was determined in part by the number and type of errors committed by the subjects. This was due to the fact that the experimenter spent additional time during each session providing written remediation of errors. The more complex the errors and the more frequently they occurred, the more time during a given session that was consumed. Steven engaged in a display of rivalry during session 21. Rate during this session was depressed due to the experimenter spending time requesting and obtaining a cessation of manual communication between Steven, Scott and Maurice. Another depression of rate occurred during session 26 due to a prompt for sentence length by the experimenter. With the exceptions of these two depressions in rate, the general trend during phase III was for a slowly increasing rate to the approximate level of 45 trials per session. Barbara was absent from session 18 to session 22. Scott was absent from session 19. Peter was absent from sessions 20 and 21. Susan was absent from sessions 22, 23, 24 and 25. Susan arrived from the infirmary late and completed only 30 minutes of session 21.

Phase IV (No Consequation) ran from session 27 to session 31. This phase was marked by the occurrence of various forms of non-sentence-writing behavior on the part of subjects throughout its duration in addition to sentence

writing behavior. During the previous 26 sessions, no subject left the room or sharpened his pencil. Subjects remained seated and wrote sentences following each stimulus. During phase IV, occurrences of leaving the experimental room for drinks of water, trips to the restroom, going to the pencil sharpener, telling jokes and stories manually, laughing, and playing with or writing on the overhead projectors increased in frequency throughout the five sessions of the phase. Rate was not depressed during this phase. During session 28, Richard completed 16 sentences and then stopped responding. He stopped responding after 41 of the 48 sentences written during session 29. Scott was absent from sessions 29 and 31. Peter was absent from sessions 30 and 31.

Phase V (Reinforcement plus Remediation) began with session 32 and ended with session 36. Rate was depressed on session 32, but increased greatly during the remaining sessions of this phase. During session 34, the subjects were responding at the highest rate of the experiment (57 sentences). The experimenter received prompts from subjects if he consumed more than a few seconds in remediating an error during this session. No subjects were absent from the five sessions of this phase with the exception of Denise during session 32.

Phase VI (Reinforcement plus Remediation for Higher-order Sentence Writing) ran from session 37 to session 41. The establishment of a new reinforcement contingency occurred in this phase. Rate was markedly depressed during the five sessions of the phase due in part to the length and complexity of the sentences written by subjects. Because subjects were writing compound and complex sentences for the most part, more time was required to remediate

errors. For example, certain of the alternatives available in the structure of a eompound sentence were illustrated to subjects. Also, sentences were longer and took more time to write during this phase than in other phases. With the exception of Susan who was absent from or late in arriving to all five sessions, no absences oecurred during this phase.

Aeeuraey of Response. Data concerning the accuracy with which subjects composed sentenees are presented in Figures 2-11. Appendix 2 eontains samples of sentences written by eaeh subject. Eaeh subjeet is represented by a figure whieh shows the pereent of total sentences which were grammatically correct for eaeh of the 41 sessions. In the eases of a subject eompleting only part of a given session. this pereentage figure was based on only that number of responses completed in the portion of the session the subject was present. Data will be described for eaeh subjeet individually. During the final session (4) of phase I, David's parents were present throughout the session. A concomitant increase in aceuraey oeeurred in the sentences written by 9 of the 10 subjeets.

Barbara's baseline accuracy was variable, ranging from 45 to 77 pereent (see Figure 2). During her first session in phase II following a five-day absence, Barbara's aceuraey was at the level of the last session of baseline completed and then rose during sueeeeding sessions. The only major reversal of this growth in accuraey occurred during session 14 when Barbara was prompted for rate by Steven and Peter. Barbara was again absent for a five-day period at the start of phase III. When she returned, her aceuracy remained high. The only further depression occurred during session 26, following a prompt for sentence length by

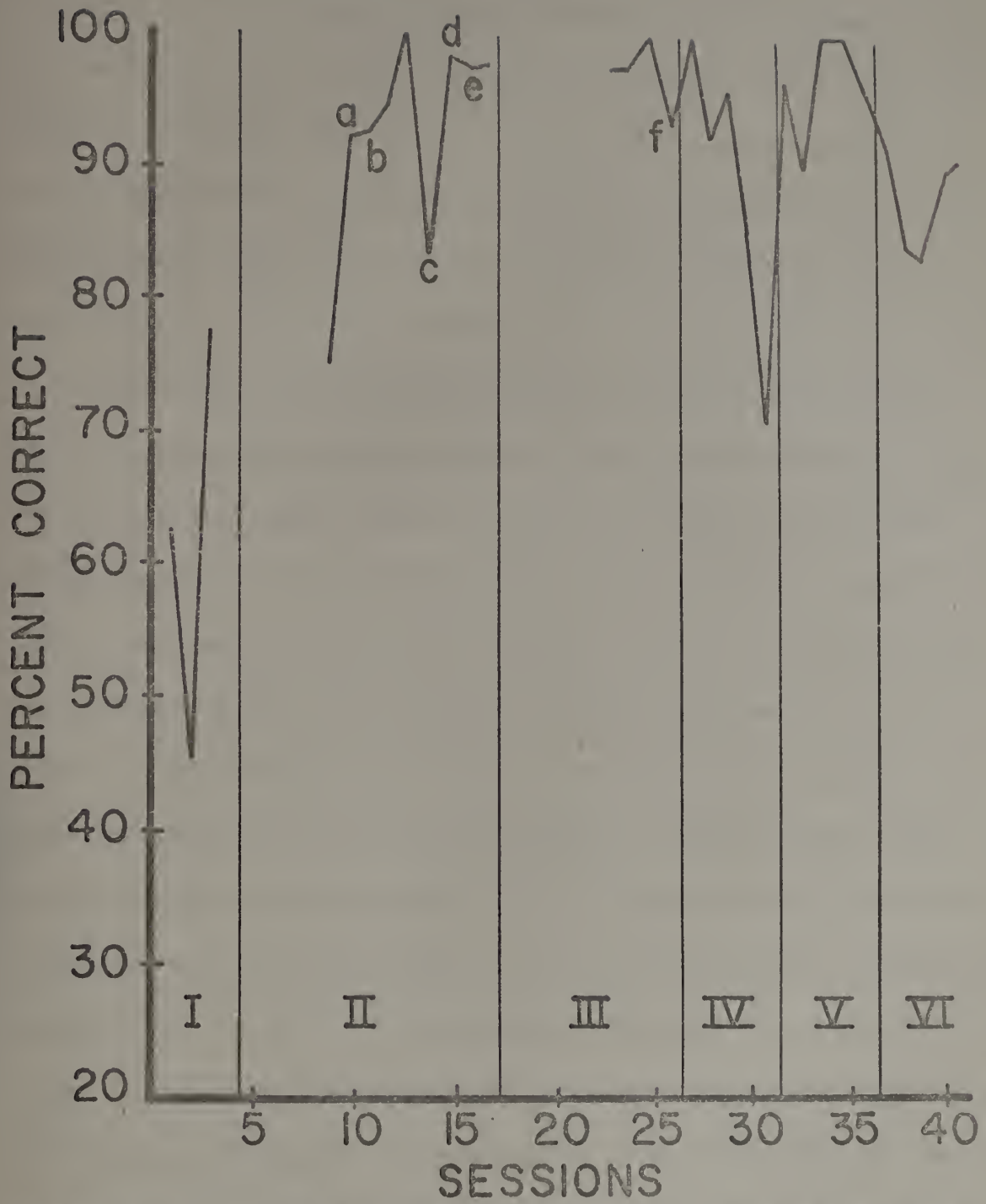


FIGURE 2 PERCENTAGE OF SENTENCES CORRECT BY SESSION FOR BARBARA

the experimenter. Accuracy declined throughout phase IV and reached baseline level by session 31. With the reinstatement of reinforcement and remediation in phase V, Barbara's accuracy returned to levels attained during phases II and III. As with all other subjects, her accuracy never dropped below 92% during phase V. As she began writing more sophisticated sentences in phase VI, her accuracy declined and then increased as the effects of reinforcement and remediation became evident. The high number of absences limited the amount of control possible over Barbara's writing.

David displayed marked growth in accuracy throughout the experiment (Fig. 3). During phase I baseline, David's accuracy ranged from 37 to 56 percent with a spurious figure reached on session four. David's parents were visiting the school on the day of the fourth session and his father had just returned from a one-year tour of duty in Vietnam. In phase II, the first two rate prompts (notes b and c) from subjects resulted in slight depressions in David's accuracy. The last rate prompt (note e) from subjects did not produce a depression of accuracy as had the earlier prompts. Accuracy remained stable throughout phase III with the exceptions of a reversal at session 21 which was concomitant with an emotional display from Steven, and following a length prompt at session 26. The initial effect of phase IV on David's work was a sizeable decrease in accuracy to less than 60% with a subsequent increase during the final two sessions in the phase to the 85-90% range. With the reinstatement, David resumed his earlier high rate of accuracy and continued to improve. Phase VI resulted in a brief depression in accuracy with a resumption of improvement.

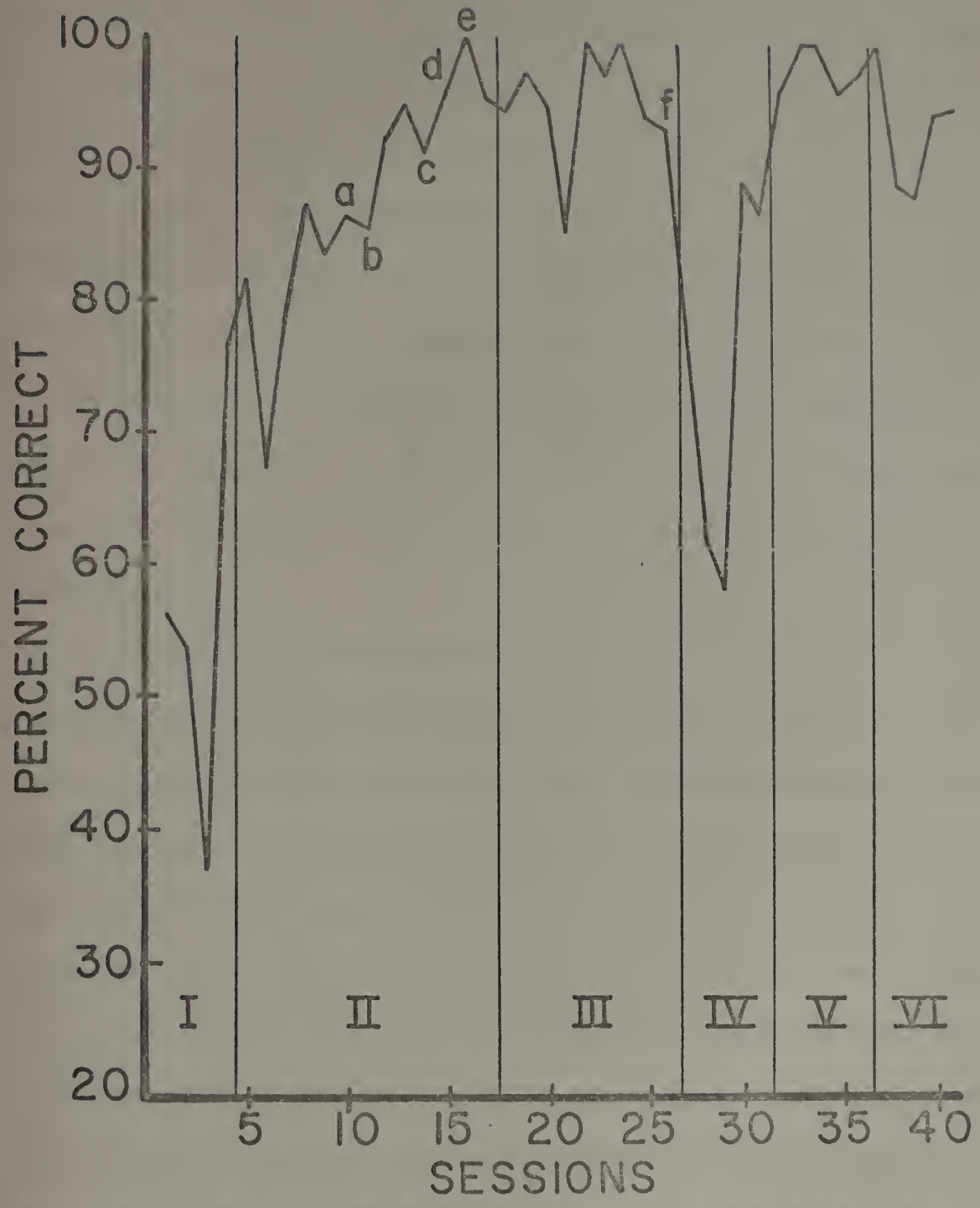


FIGURE 3 PERCENTAGE OF SENTENCES CORRECT BY SESSION FOR DAVID

The accuracy of sentences composed by Denise (Fig. 4) during phase I ranged from 33 to 54%. The start of phase II produced a jump in accuracy to 84% which was followed by a general slow increase throughout the remaining sessions of the phase. Phase III resulted in a general decrease in accuracy for Denise. Session 21 resulted in the greatest drop in Denise's accuracy. This decrease was concomitant with the emotional display from Steven as was the depression of David's accuracy. The termination of reinforcement and remediation in phase IV resulted in a depression of accuracy initially with a shift upward in the latter sessions of the phase. Reinstatement of consequation in phase V generated a resumption of high accuracy. The new contingency during phase VI was accompanied by a depression of Denise's accuracy with a subsequent upward shift during session 41.

Baseline accuracy percentages for Lorna (Fig. 5) range from 56 to 73. During the first several sessions of phase II, Lorna wrote more and more inaccurately, but rapidly improved during the latter sessions and maintained a high level of accuracy. The beginning of phase III also resulted in a depression in accuracy, but of a minor nature, and was followed by the same sustained high degree of accuracy. Initially, Lorna's accuracy remained high when consequation was terminated in phase IV, but dropped to a point just above baseline rates. Reinstatement of consequation in phase V produced 100% accurate responses with the exception of the last session in the phase. This level was maintained during the first session of phase VI. As Lorna attempted more complex and lengthier sentences, accuracy decreased then increased at the end of the phase.

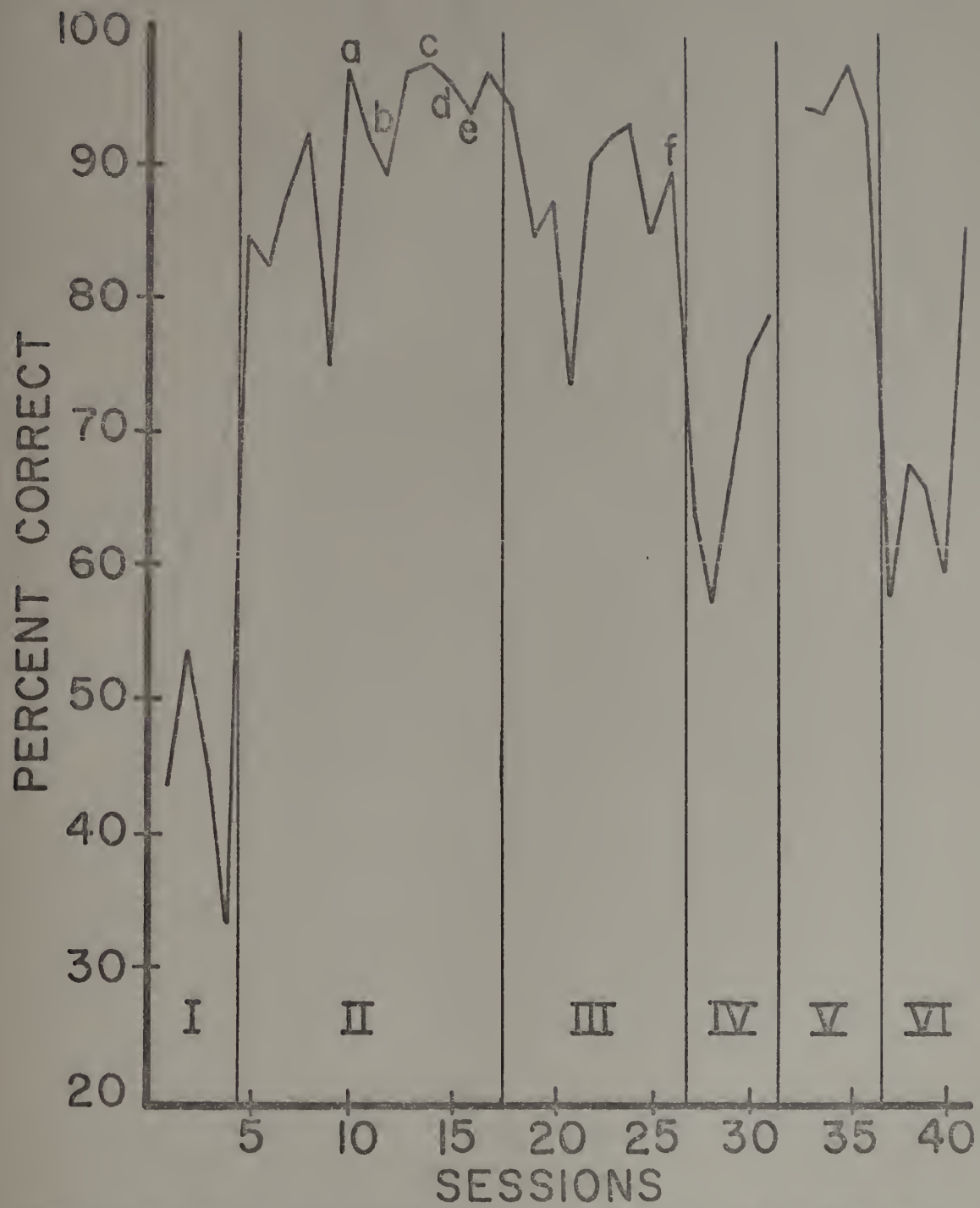


FIGURE 4 PERCENTAGE OF SENTENCES CORRECT BY SESSION FOR DENISE

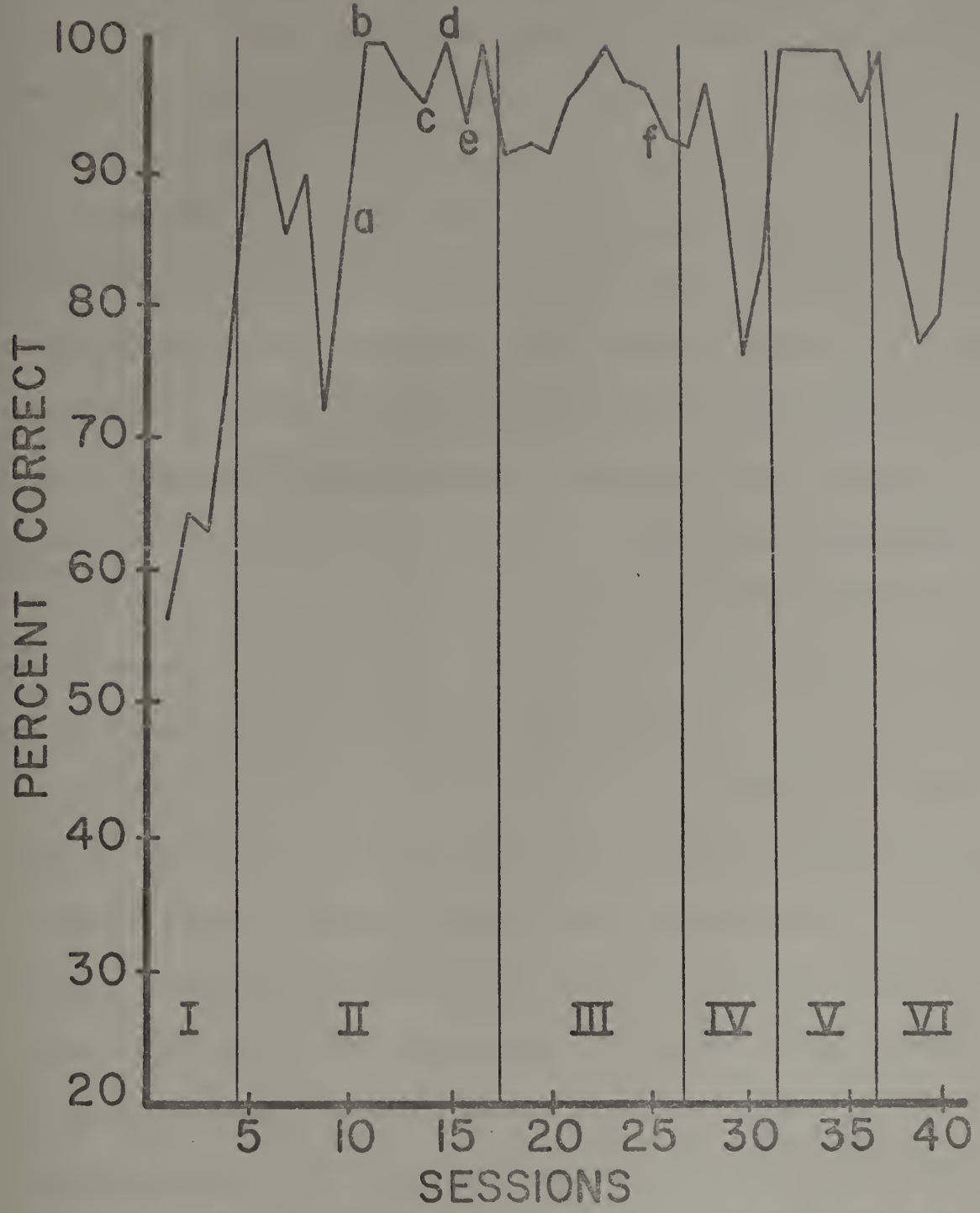


FIGURE 5 PERCENTAGE OF SENTENCES CORRECT BY SESSION FOR LORNA

Maurice composed sentences whose accuracy ranged from 46 to 57% during phase I (Fig. 6). Following a five-day absence, Maurice began working in phase II at a low level of accuracy which improved greatly throughout the remaining sessions of the phase, with the exception of one reversal. This reversal occurred during session 15 and was concomitant with the prompt for accuracy from the experimenter. In phase III, Maurice's accuracy was maintained with the exception of a marked depression during session 21. This was the session in which Steven engaged in an emotional display. Most of Steven's agression was directed toward Maurice. Termination of reinforcement and remediation in phase IV resulted in a reduction of accuracy to a point roughly between that occurring in phases II and III and that occurring in baseline. With the reinstatement Maurice resumed his earlier level of highly accurate composition. Phase VI produced the depression of accuracy in early session which was recovered by the last session that was seen in the performance of other subjects.

Peter produced sentences which varied greatly in accuracy during phase I (Fig. 7). Instatement of reinforcement in phase II resulted in a slowly increasing level of accuracy which was continued with the introduction of remediation in phase III. Termination of consequation in phase IV produced only a slight depression of accuracy in Peter's composition. He was only present for 60% of the sessions in phase IV however. Phase V conditions generated a return to near 100% accuracy. After an initial depression in the early portions of phase VI, Peter's accuracy rose to above 90%. Although Peter made relatively few errors in composition throughout the experiment, when such errors occurred

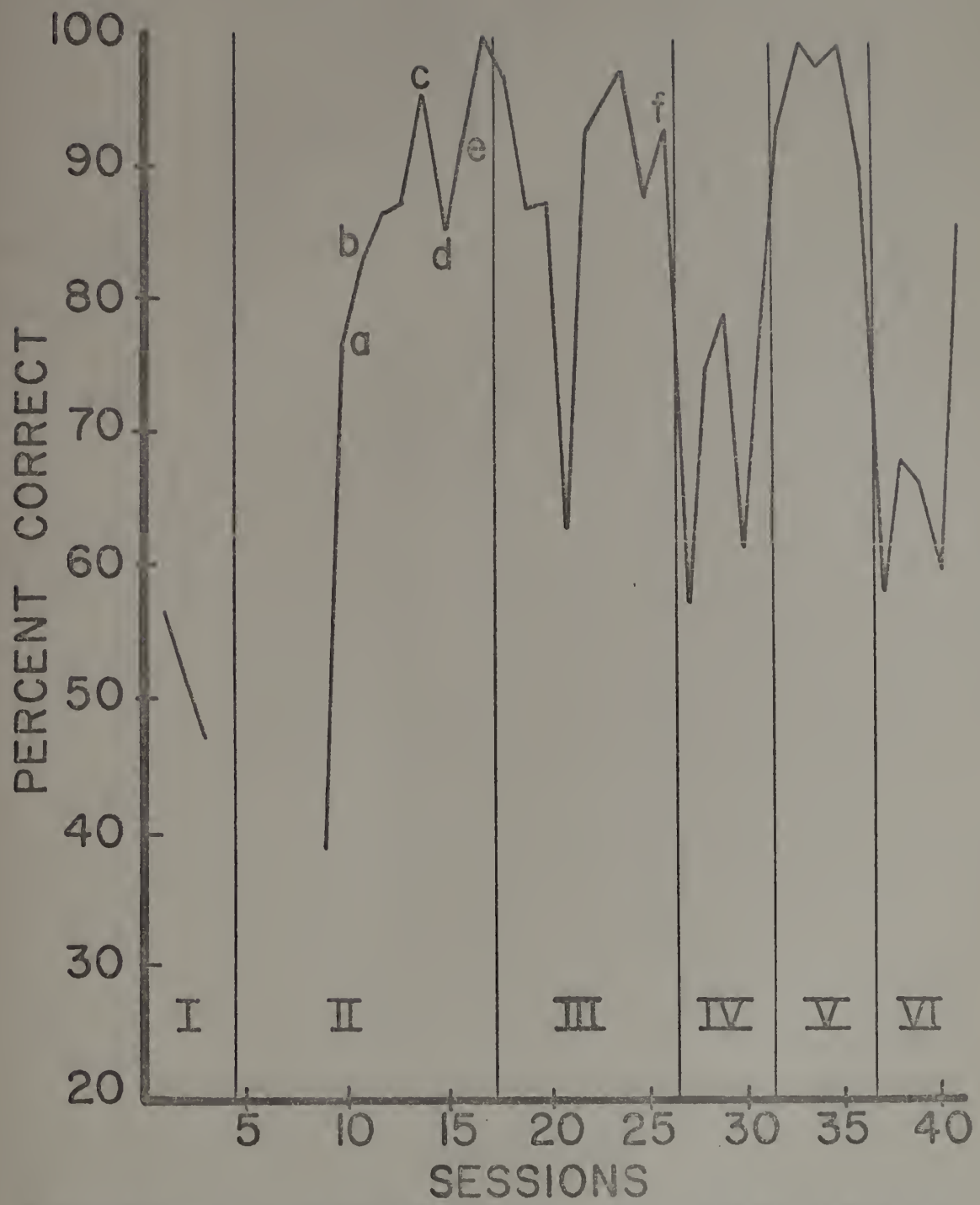


FIGURE 6 PERCENTAGE OF SENTENCES CORRECT BY SESSION FOR MAURICE

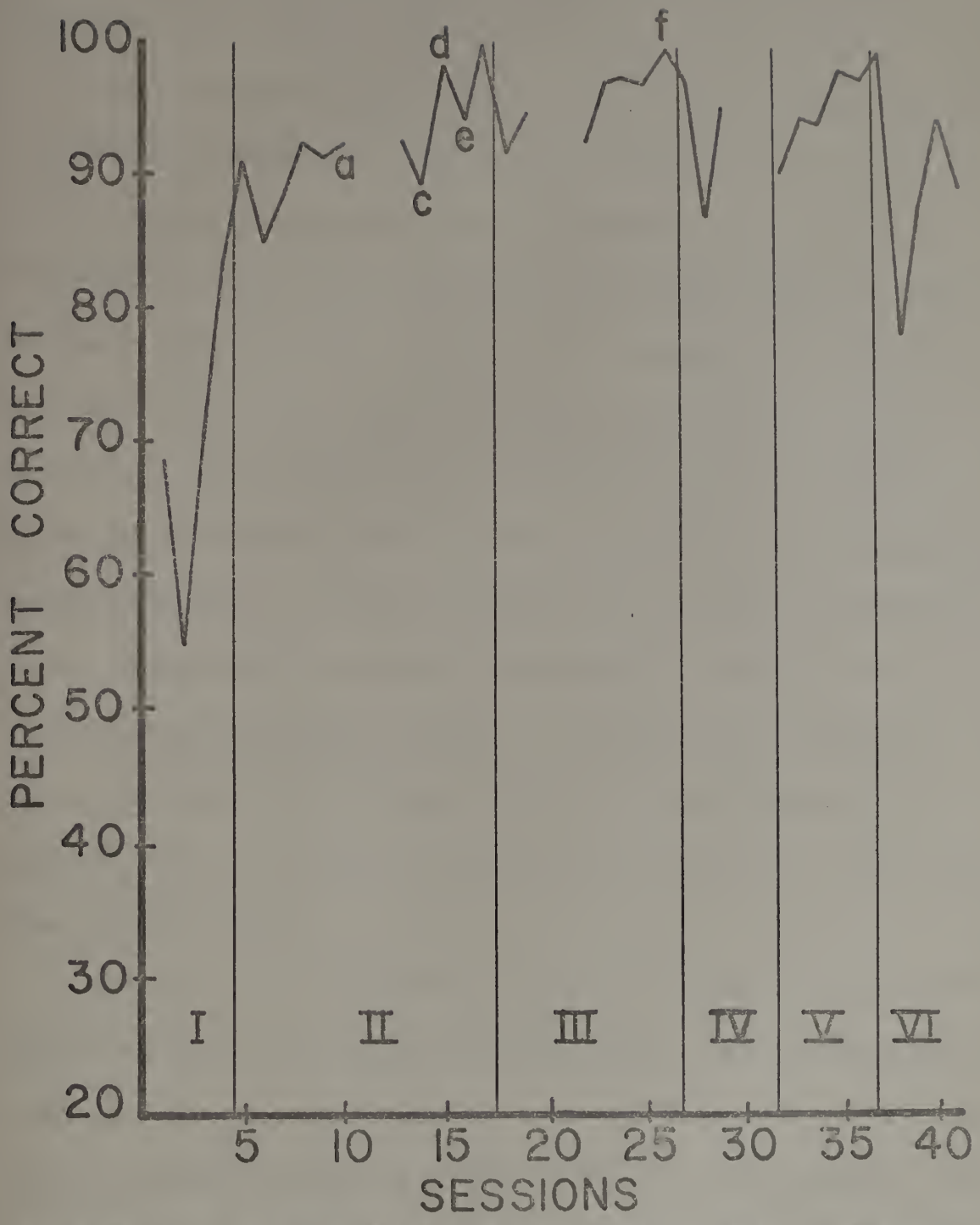


FIGURE 7 PERCENTAGE OF SENTENCES CORRECT BY SESSION FOR PETER

emotional displays invariably followed. That is, after writing a sentence and receiving no point and, when called for, remediation, Peter would often weep, stare at his hands, or engage in other sorts of emotional behaviors.

Richard's baseline rate of accuracy ranged from 25 to 48 percent (Fig. 8). As with Barbara and Maurice, when Richard returned to school following a five-day absence, his accuracy during phase II increased and was maintained at reasonably high levels. The prompts for rate by subjects (notes b, c, and e) resulted in a downward shift in accuracy. The prompt for accuracy by the experimenter (note d) was effective in producing a higher level of accuracy for the session in which it occurred only. As with Denise, David, and Maurice, a depression in Richard's accuracy occurred with Steven's emotional display during session 21 of phase III. Phase IV resulted in varied changes in accuracy with a marked downward shift. High levels of accuracy were regained, however, with reinstatement of consequation in phase V. The familiar early depression of accuracy with a later recovery in phase VI occurred in the writing of this subject. The early downward shift was not as pronounced for Richard as it was for some other subjects, however.

Following a low level of accuracy during session 1, Scott produced a moderately high level of accuracy during baseline (Fig. 9). Scott's accuracy varied within each phase to a considerable extent although the range decreased and the general trend was toward higher accuracy as the experiment progressed. This variability increased in phase IV. However, Scott was present for only 60% of the sessions of this phase. With the reinstatement of consequation in phase V,

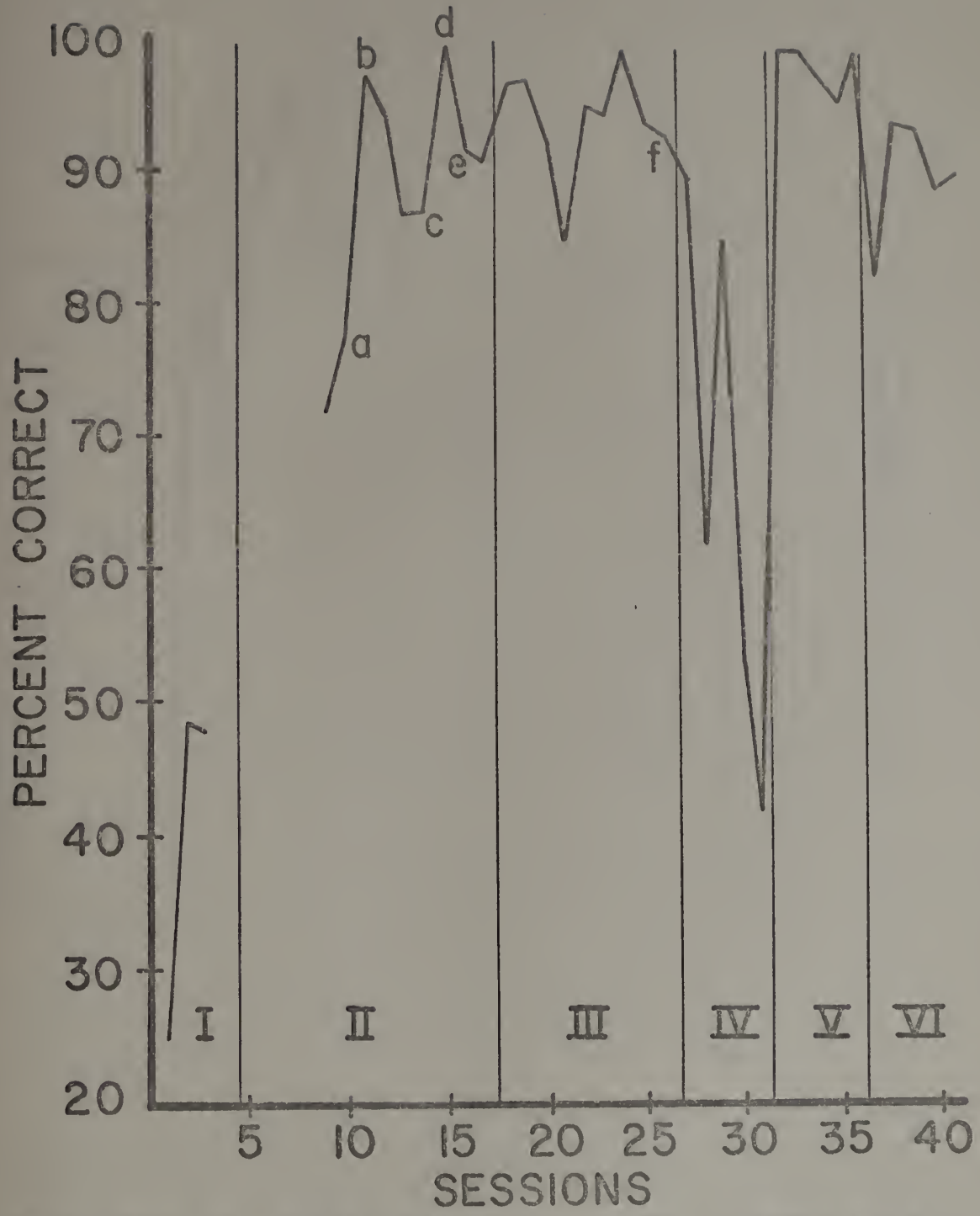


FIGURE 8 PERCENTAGE OF SENTENCES CORRECT BY SESSION FOR RICHARD

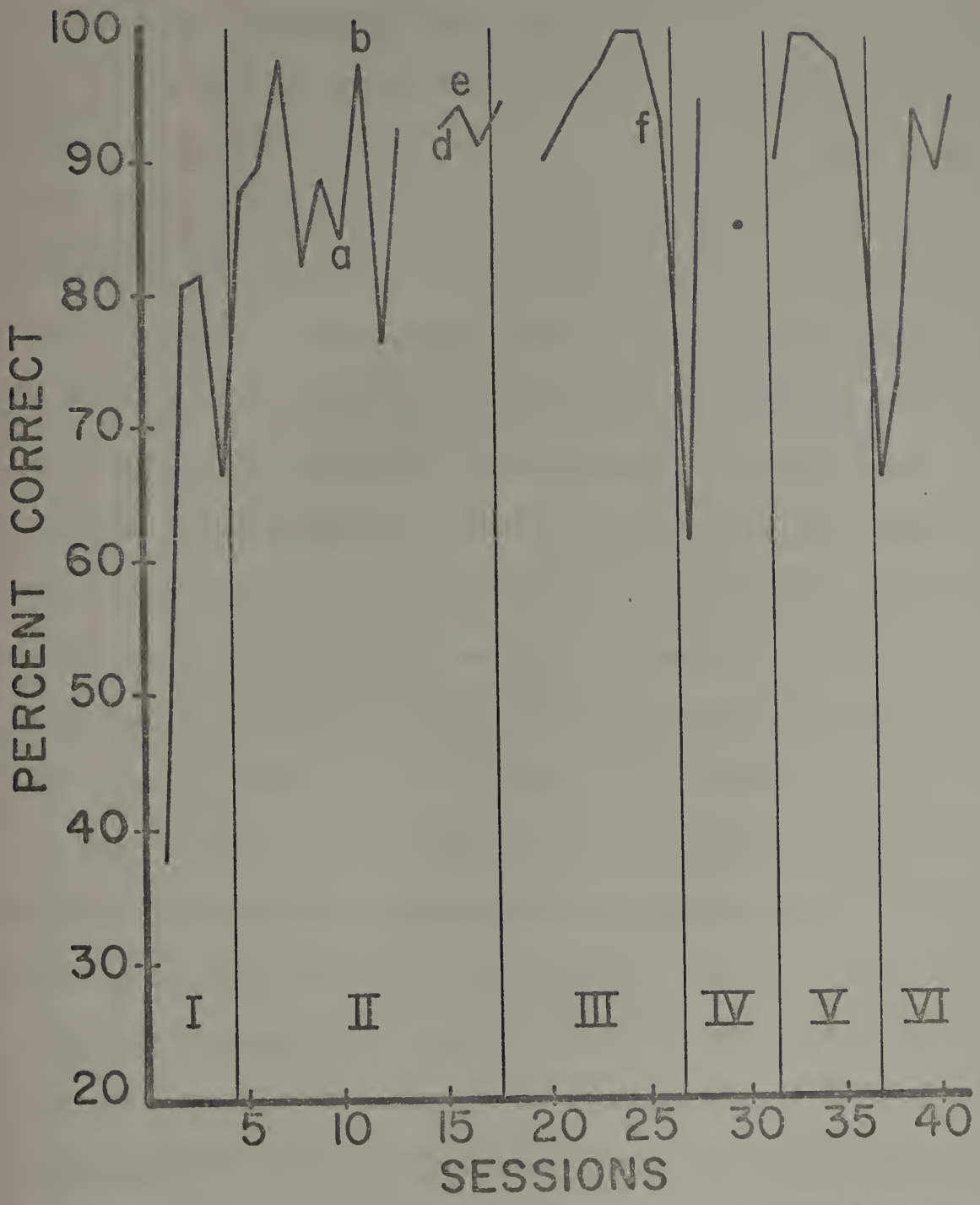


FIGURE 9 PERCENTAGE OF SENTENCES CORRECT BY SESSION FOR SCOTT

Scott's accuracy improved considerably and ranged from 92 to 100%. The same early depression of accuracy and later resumption of former levels occurred in Scott's performance in phase VI as it had for other subjects.

After an initial low accuracy level during session 1, Steven's writing stabilized at roughly 64% during baseline (Fig. 10). His accuracy rapidly increased with the onset of consequation and stabilized at a level ranging from 95 to 100% in phases II and III. There was only one major reversal which occurred during session 9 in phase II. The level and variability of accuracy shifted downward and increased during phase IV. With the resumption of consequation in phase V and throughout phase VI, Steven did not commit a single grammatical error in his writing. The emotional display produced in session 21 by Steven took the form of manual signing to other subjects berating them for errors. The manner in which the signing was performed was hostile and agressive. Time was taken during this session by the experimenter in terminating Steven's emotional behavior. No recurrences of this type of behavior were observed.

Susan's baseline rate of accuracy was very stable (Fig. 11). Her accuracy improved markedly with the onset of consequation and was maintained at 93% or higher for the second half of the sessions in phase II. Susan was absent from 44% of the sessions of phase III and her accuracy declined during those sessions at which she was present. Termination of consequation produced an increase in the variability of Susan's accuracy with a general downward shift. Resumption of consequation in phase V resulted in a return to stable performance at high levels of accuracy. Susan's accuracy was never less than 92% in phase V. Because of

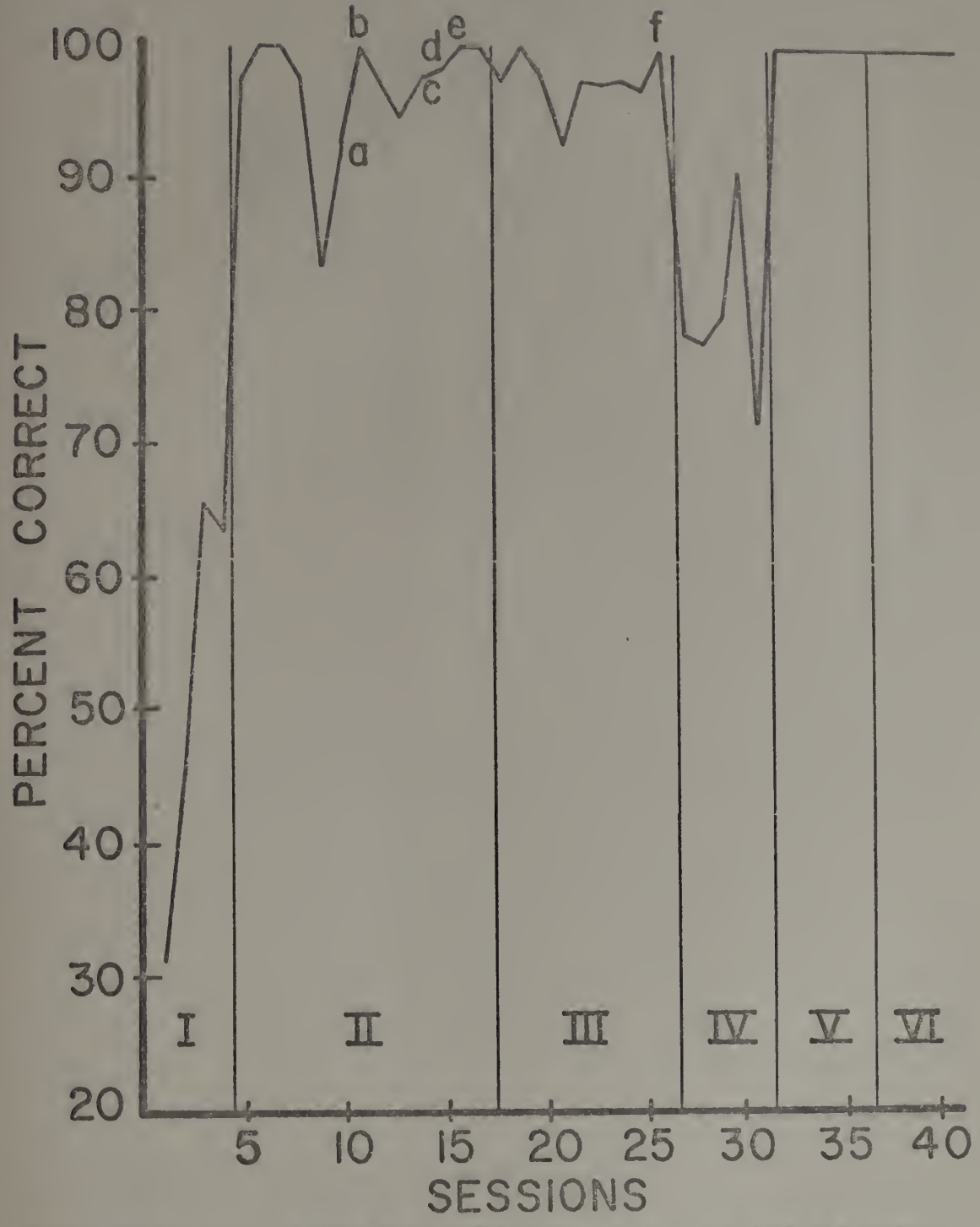


FIGURE 10 PERCENTAGE OF SENTENCES CORRECT BY SESSION FOR STEVEN

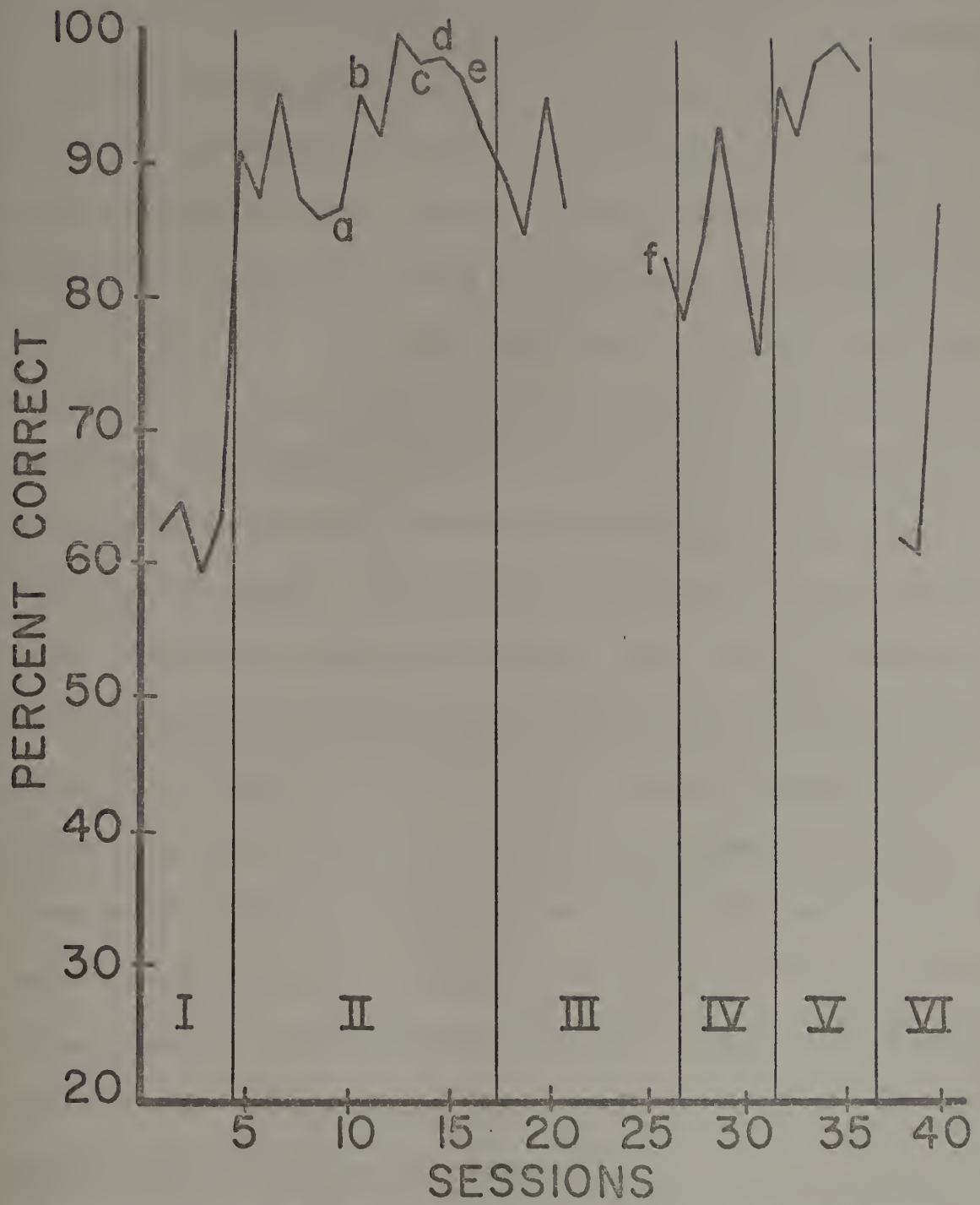


FIGURE II PERCENTAGE OF SENTENCES CORRECT BY SESSION FOR SUSAN

the requirements for medication and due to an absence during phase VI, Susan's performance is not as reliable as it would have been with full attendance. However, the typical early downward shift in accuracy and later recovery is present.

Number of Words Per Sentence. The inclusion of this measure was due to the fact that the probability of grammatical errors increased as the number of words in sentences increased. Data are presented in Figures 12-21. A general summary of the data from all subjects will rpovide an accurate description of the results obtained from this dependent variable due to the fact that, with few exceptions, the data are quite consistent from subject to subject. Baseline data show that subjects wrote sentences ranging roughly from six to eight words in length. With the onset of consequation a consistent shortening of sentences occurred in the writing of all subjects. The occurrence of remediation in phase III resulted in the production of somewhat longer sentences. The prompt for length during session 26 resulted in marked increases in sentence length for Barbara, Denise, and Lorna. All subjects increased the length of sentences in response to the prompt. The effect of Steven's emotional display during session 21 was to increase sentence length for those subjects also showing a decrease in accuracy. Sentence length and variability remained stable for the rest of the sessions until the end of phase V. The establishment of the new reinforcement contingency in phase VI resulted in the doubling of sentence length for all subjects. Generally, sentence length varied inversly with accuracy.

Types of Grammatical Errors. Since one of the principal objectives of the experiment was to examine the effect of teacher-student interaction during

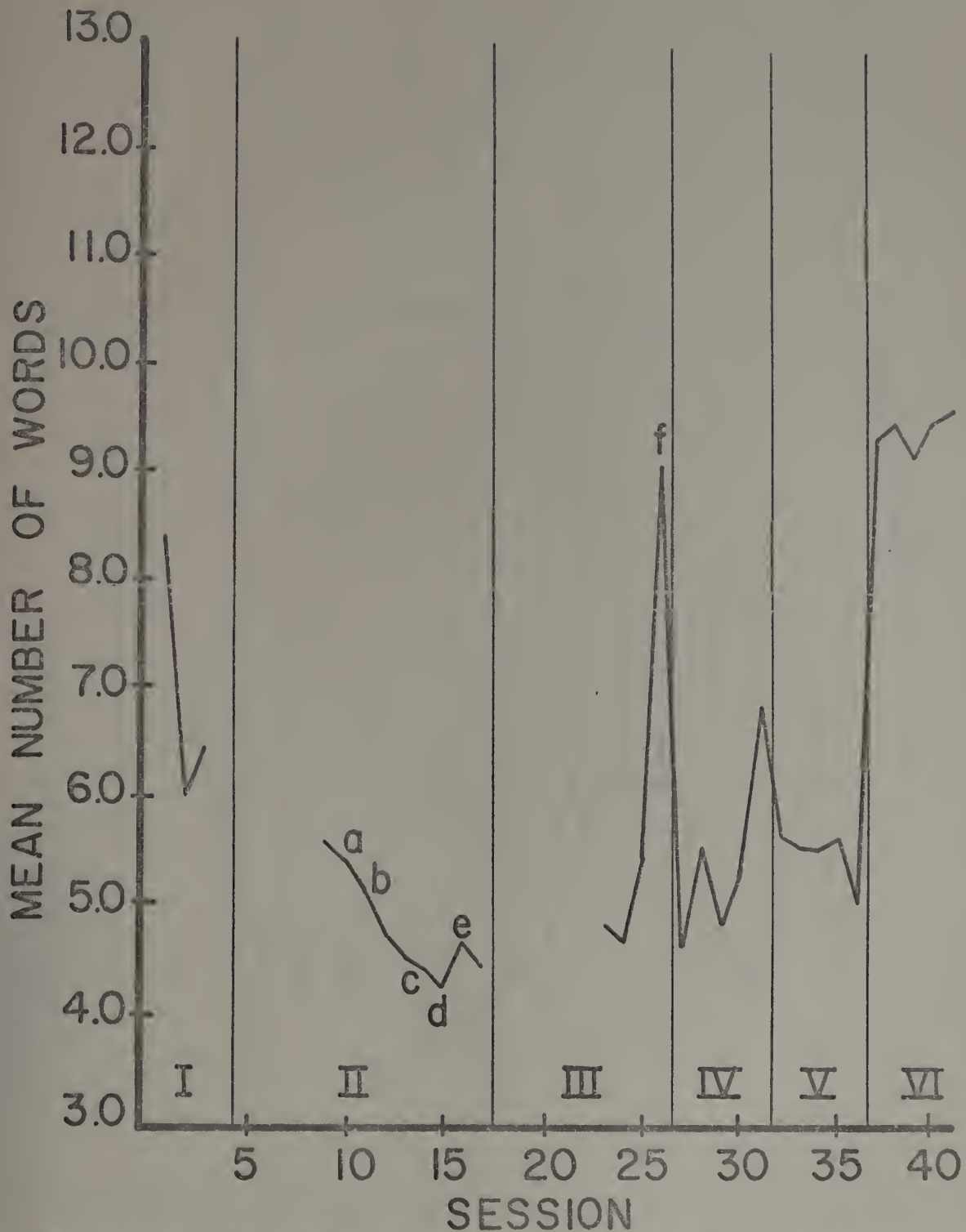


FIGURE 12 MEAN WORDS PER SENTENCE BY SESSION FOR BARBARA

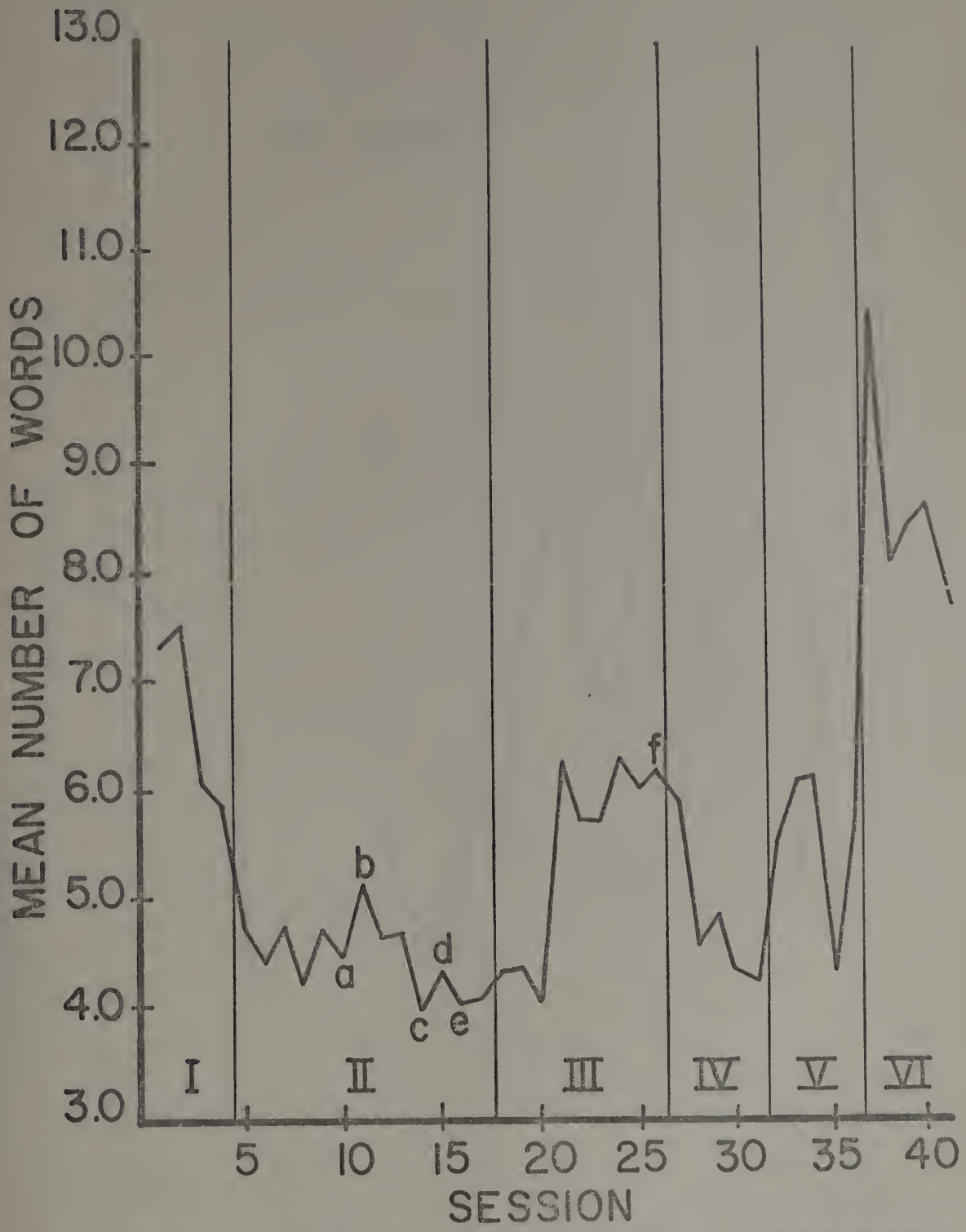


FIGURE 13 MEAN WORDS PER SENTENCE BY SESSION FOR DAVID

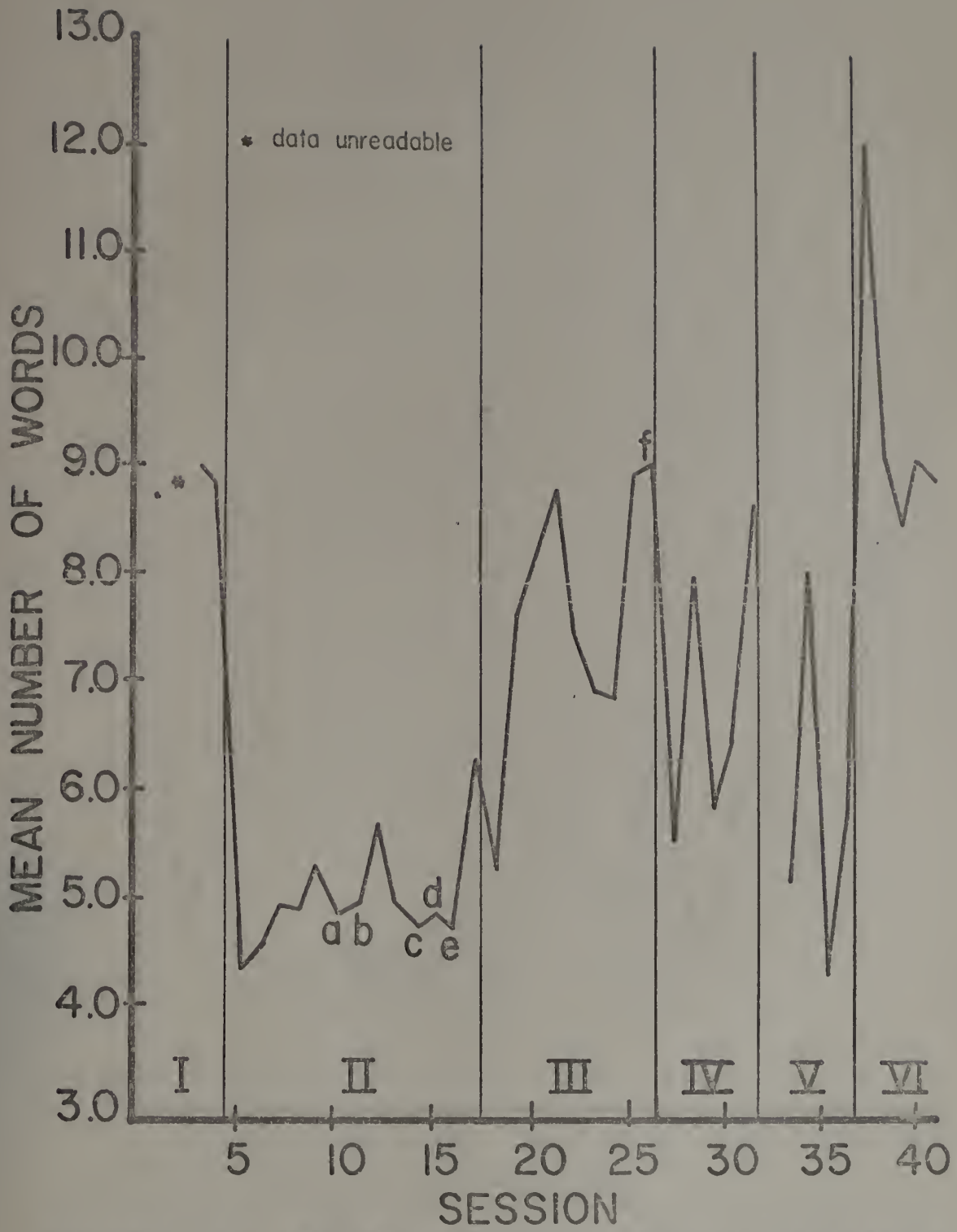


FIGURE 14 MEAN WORDS PER SENTENCE BY SESSION FOR DENISE

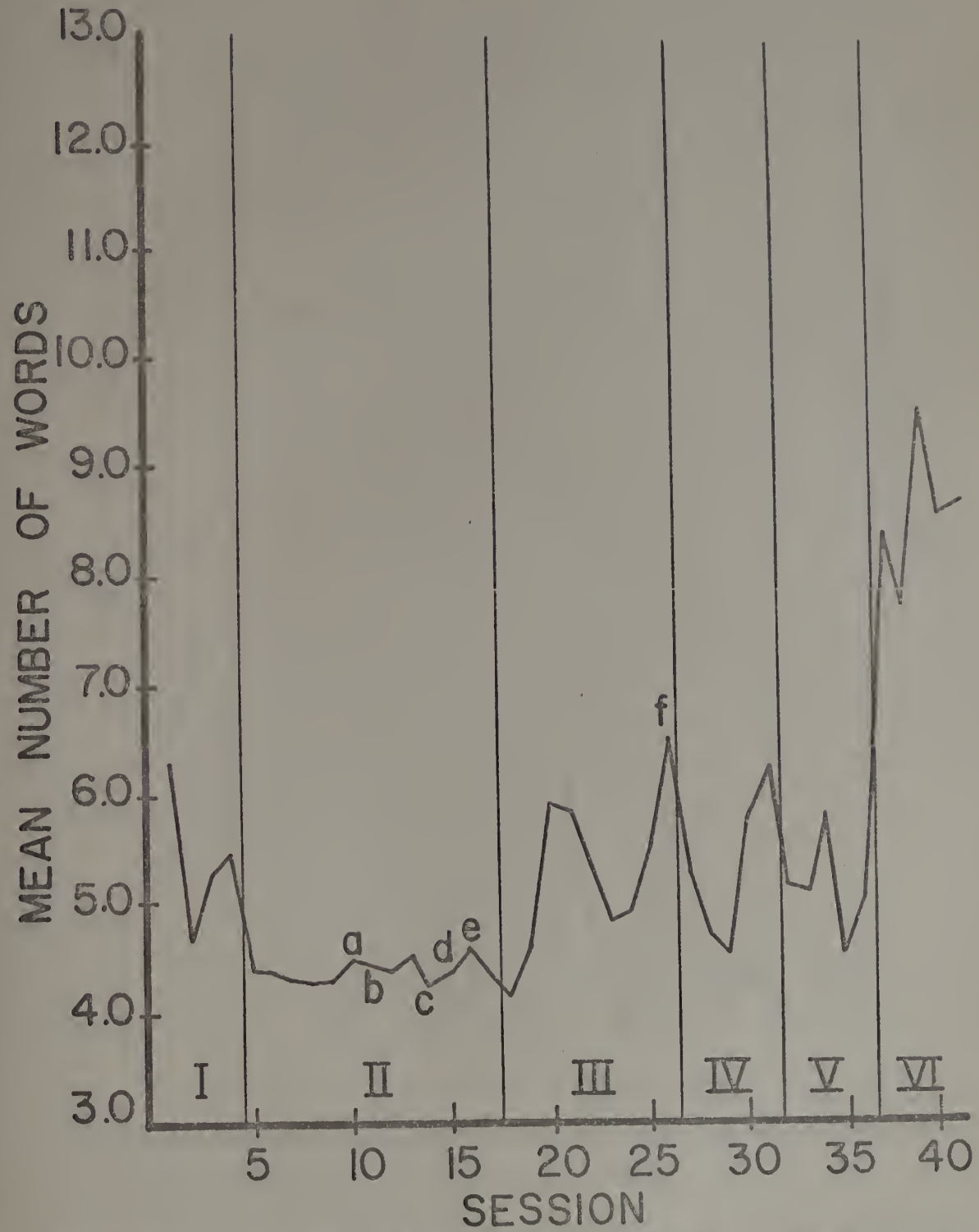


FIGURE 15 MEAN WORDS PER SENTENCE BY SESSION FOR LORNA

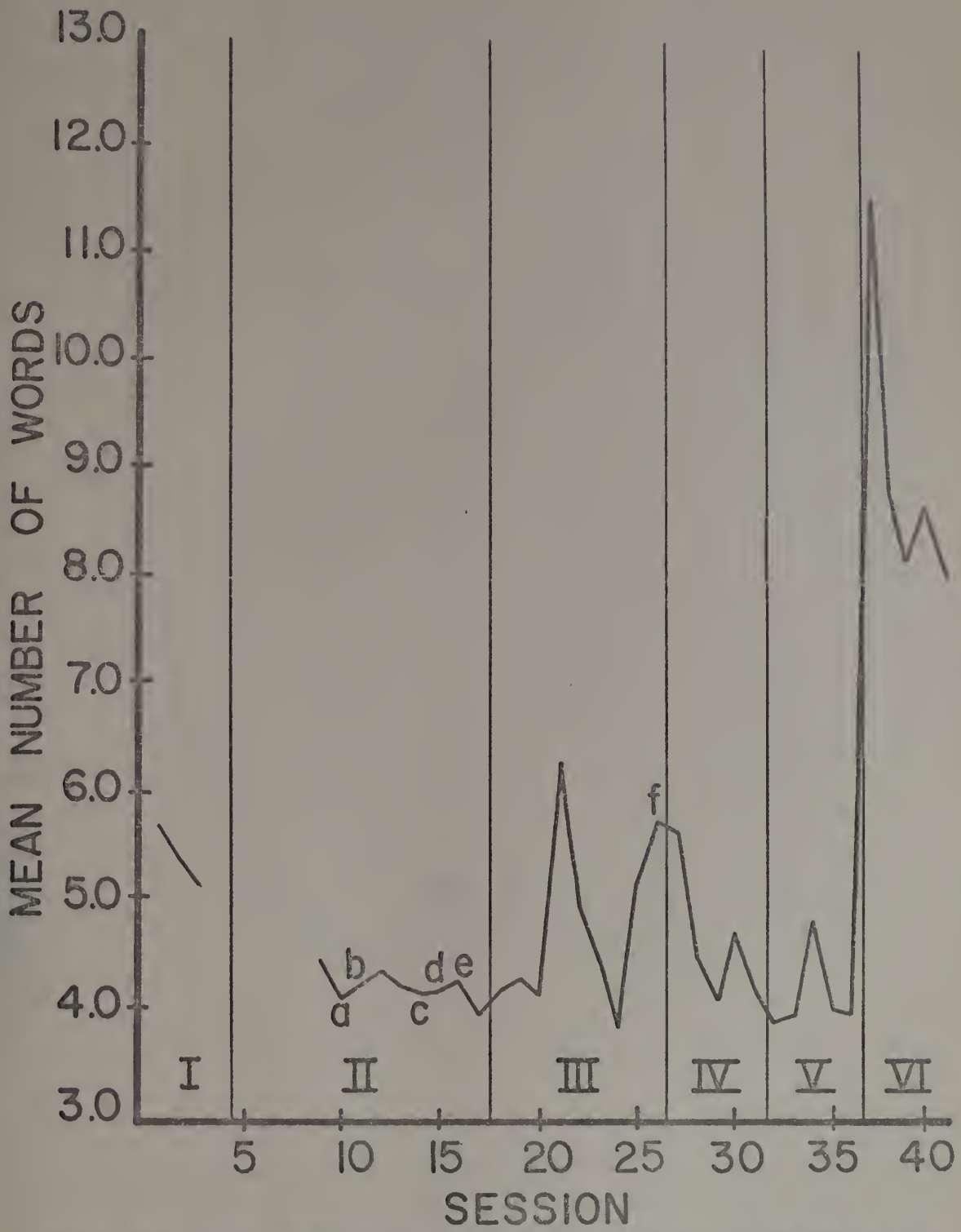


FIGURE 16 MEAN WORDS PER SENTENCE BY SESSION FOR MAURICE

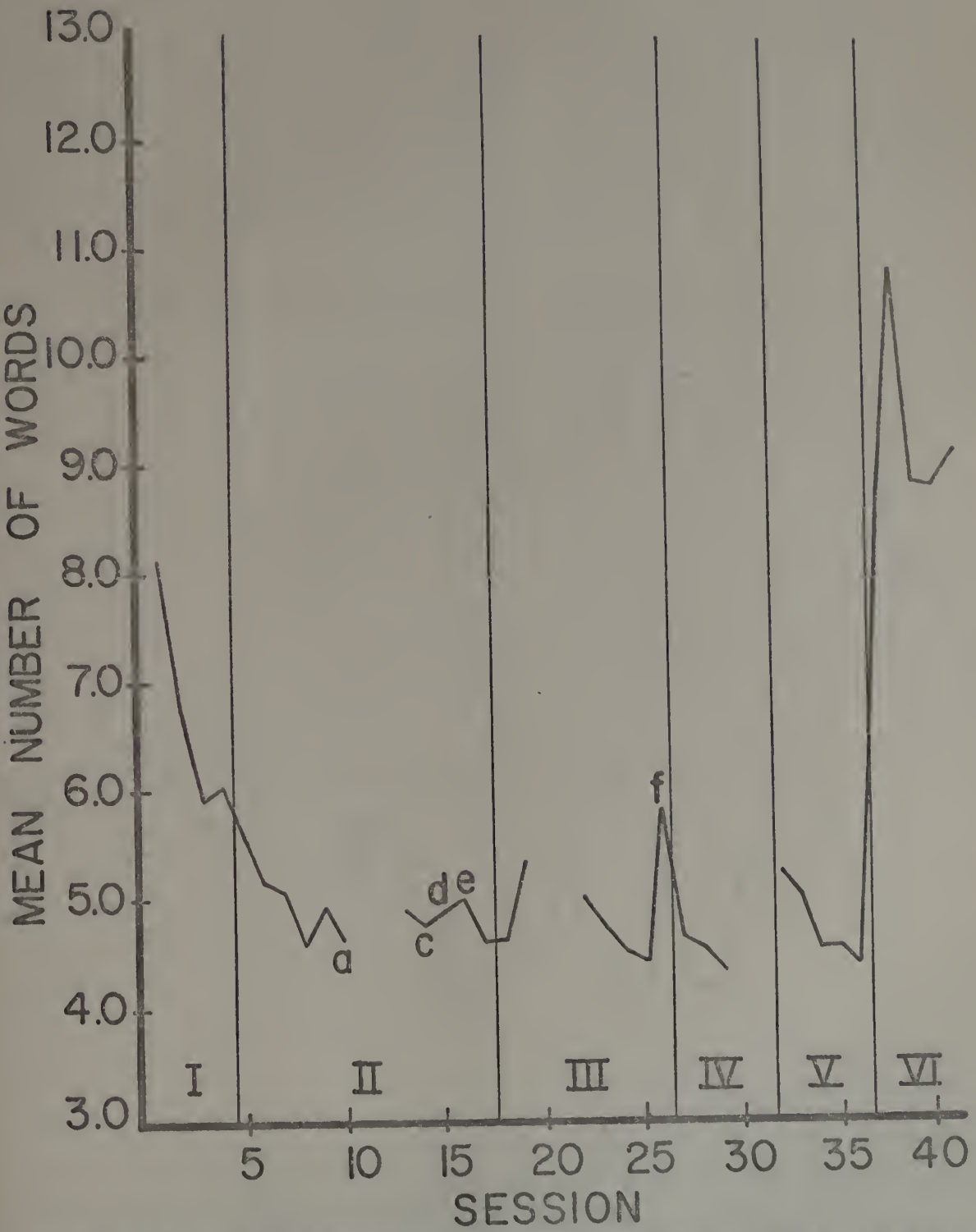


FIGURE 17 MEAN WORDS PER SENTENCE BY SESSION FOR PETER

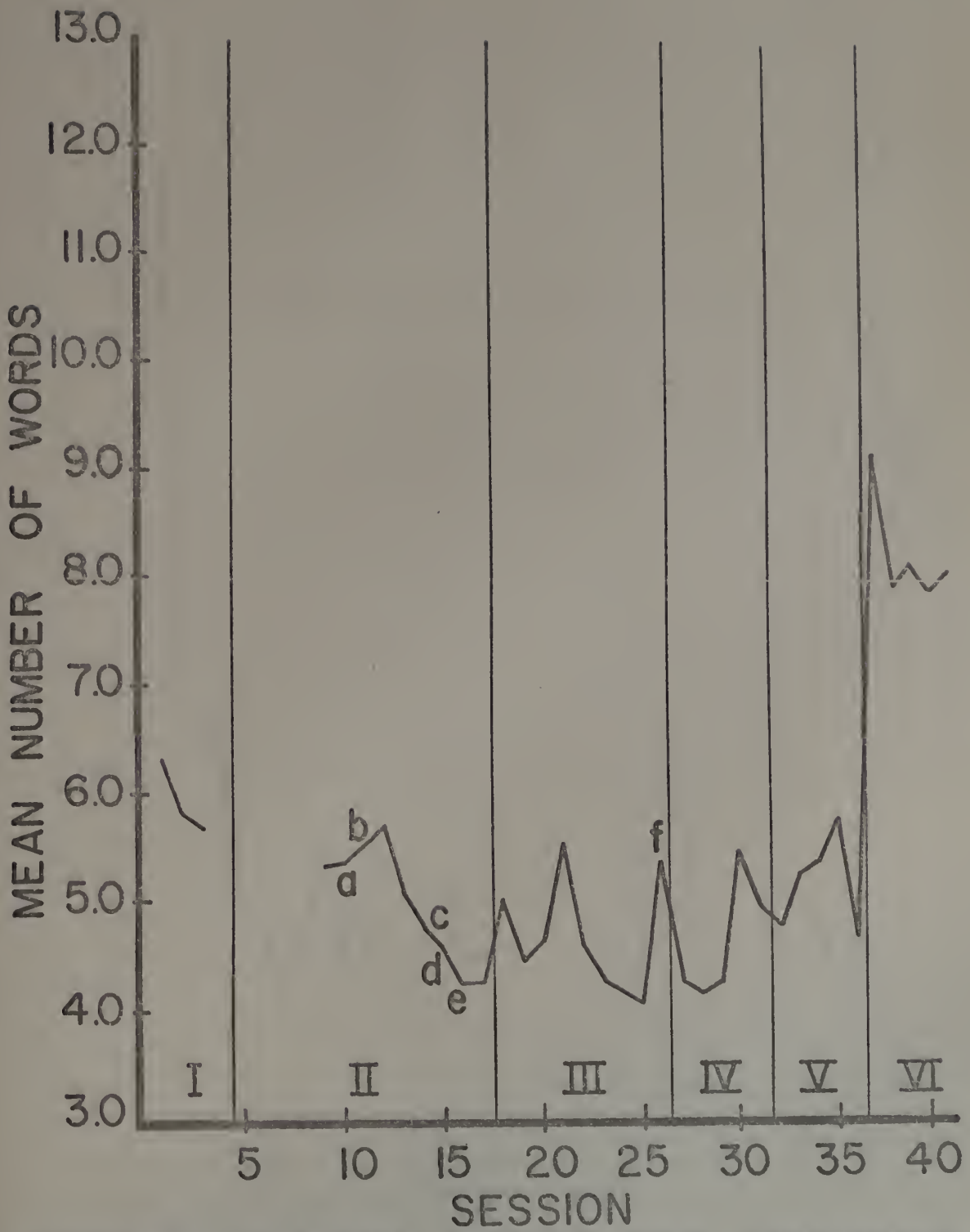


FIGURE 18 MEAN WORDS PER SENTENCE BY SESSION FOR RICHARD

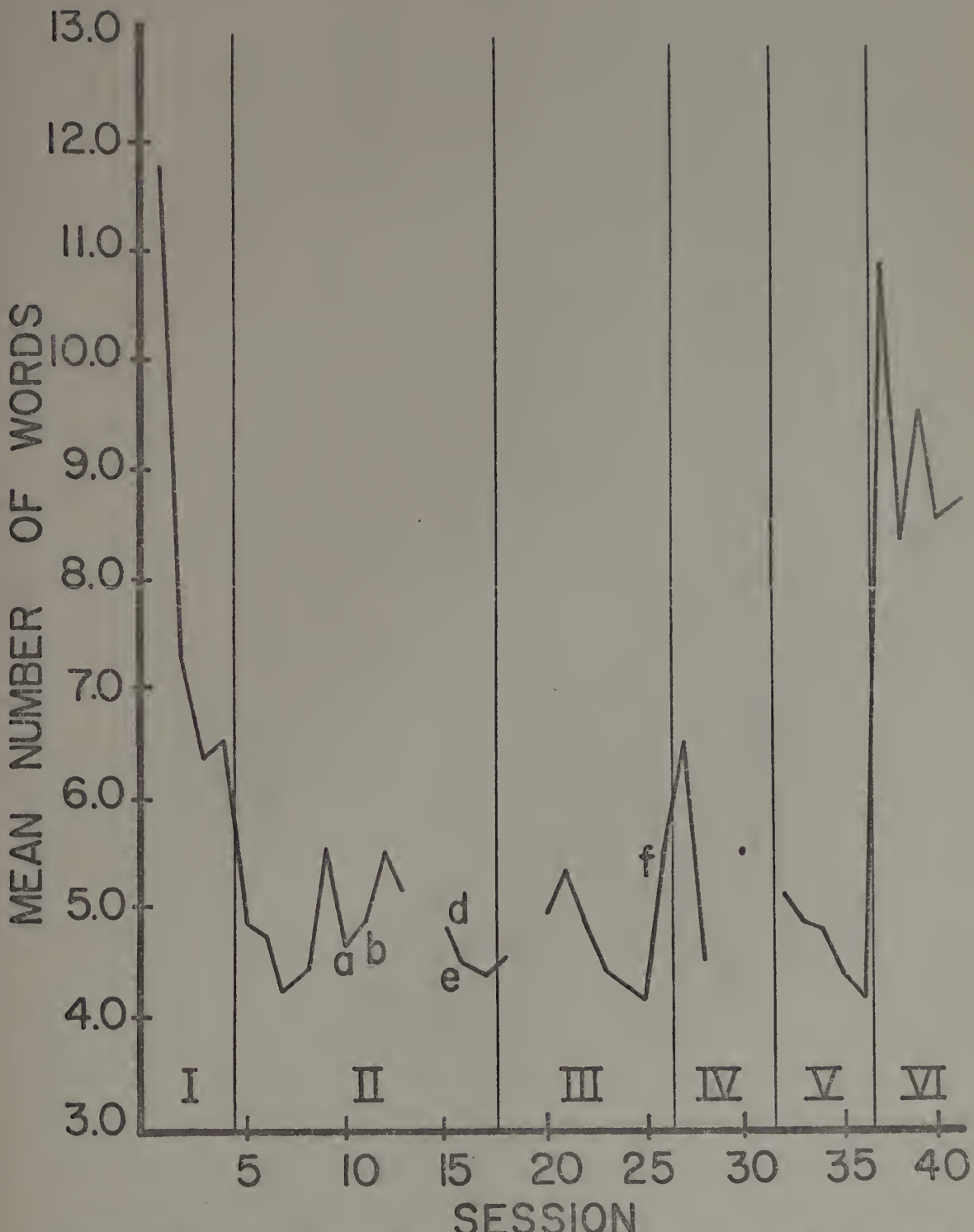


FIGURE 19 MEAN WORDS PER SENTENCE BY SESSION FOR SCOTT

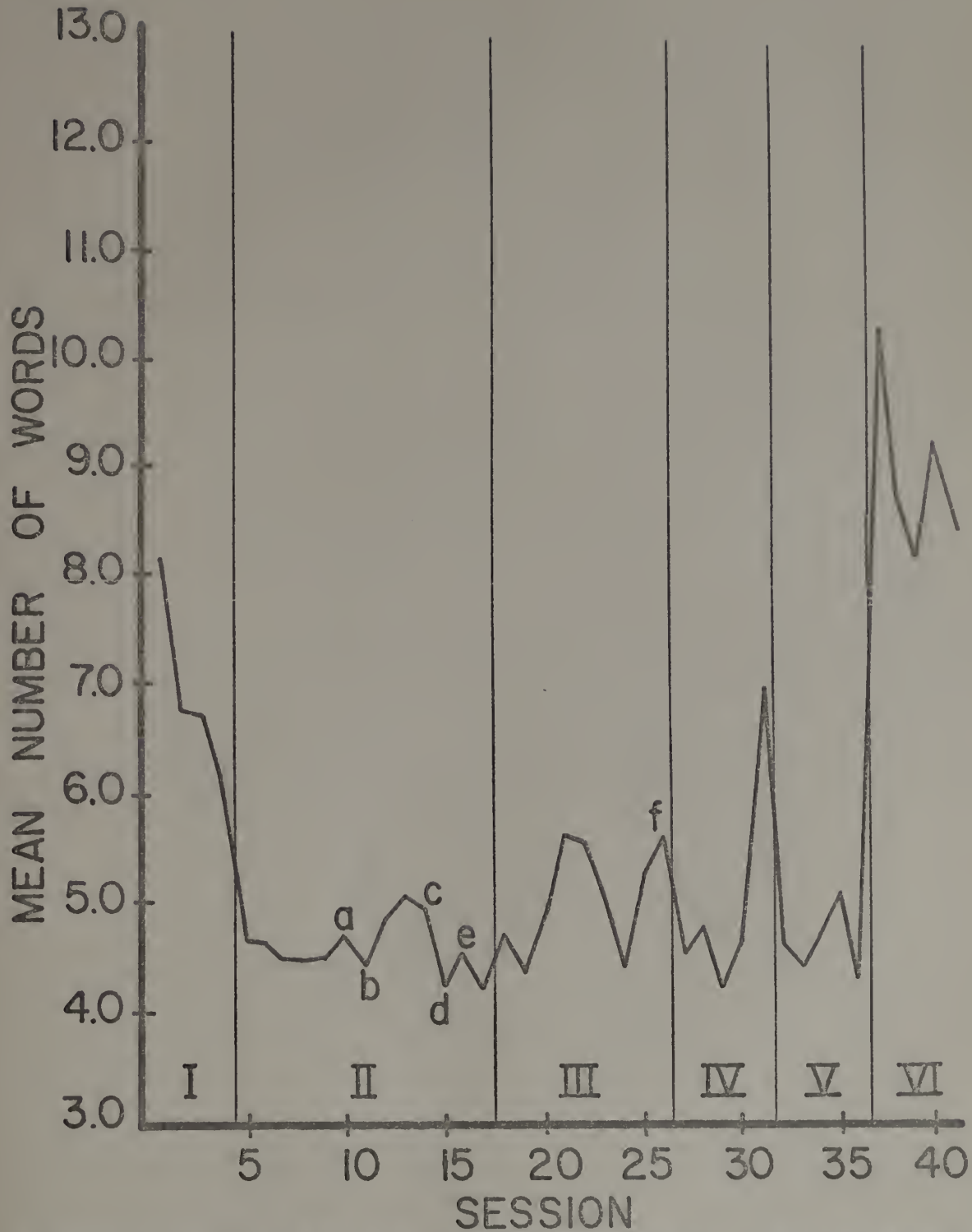


FIGURE 20 MEAN WORDS PER SENTENCE BY SESSION FOR STEVEN

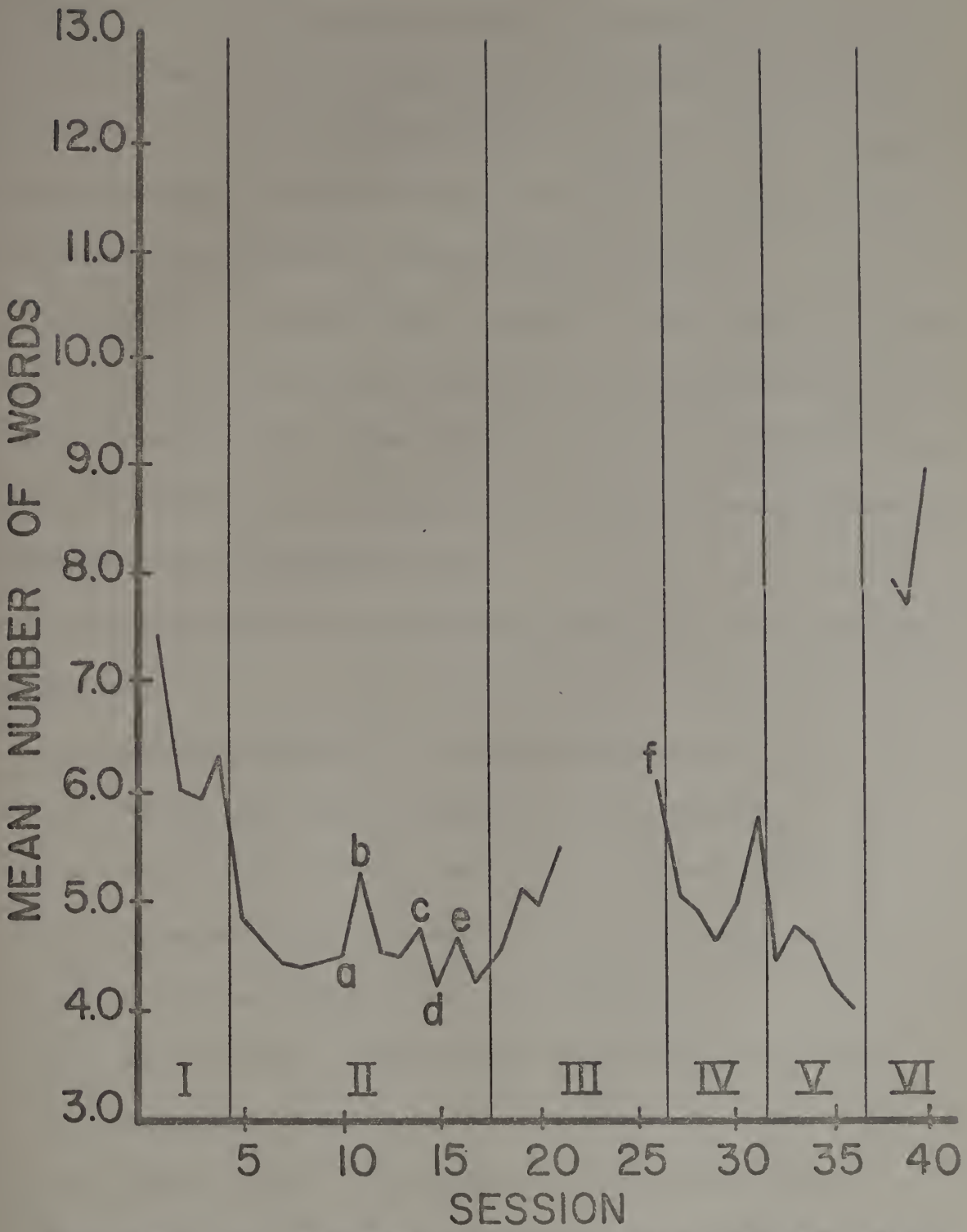


FIGURE 21 MEAN WORDS PER SENTENCE BY SESSION FOR SUSAN

remediation on the process of sentence writing, the types of grammatical errors made by the 10 subjects were tabulated. The earlier discussion of the three dependent variables has shown the effects of the token economy and remediation. specifically, the effects of remediation were shown in the changes in accuracy and sentence length. In order to provide greater detail in the analysis, the errors made by each subject were categorized after each session.

The errors were tabulated into 13 categories. These categories were not developed prior to the experimental sessions, but were instead based on the products of the subjects. That is, the 1,731 grammatical errors made by the subjects over all 41 sessions were of 13 types. A given sentence written by a subject could contain more than one grammatical error.

The categories and descriptions of the types of errors which emerged from the data were:

1. Spelling: Misspelled or incompletely written words.
2. Word Order: Misplaced subjects, verbs, or modifiers.
3. Verb Error: Verb expressed in an incorrect tense or case.
4. Incomplete or Spliced Sentence: Missing verb, subject or object, or incorrect joining of phrases or clauses.
5. Word Omission: Sentence written with missing pronoun, adverb, preposition, or article.
6. Word Insertion: Sentences written with superfluous words.
7. Plural Error: Nonagreement of number where plural form of word was used when the singular form was called for.

8. Singular Error: Nonagreement of number where singular form of word was used when the plural form was called for.
9. Wrong Word: Inappropriate word used such as in "the hands of the cat."
10. Article Error: Inappropriate use of definite or indefinite article.
11. Preposition Error: Use of one preposition when another is called for.
12. Adverb Error: Use of one adverb when another is called for.
13. Partitive Error: Inaccurate use of idiomatic expression for collections or parts of objects such as "part of cake" for "piece of cake."

Data concerning types of errors are presented in Tables 4 to 13. Error densities were calculated by summing the number of errors of one type committed by a subject during the sessions comprising one experimental phase at which he was present. This sum was then divided by the number of sessions. For example, Barbara (see Table 4) committed one verb error in phase I. Since she was absent from one of the four sessions, the error density becomes 0.33. A more sensitive measure of error density could have been derived by basing the means on the number of sentences written in each phase, but the resulting numbers would have been exceedingly small. A density of 3.00 therefore indicates that three errors of a given type occurred on the average in each of the sessions in a phase. For example, Table 7 is read in the following manner: The error density of 3.00 in row one column three means that Lorna committed three verb errors on the average in each of the four sessions of phase I. A

density figure of 0.20 indicates that an error of a given type occurred on the average of once every five sessions. Again using Table 7 as an example, row four, column one reports a density of 0.20 which means that Lorna made one spelling error during the five sessions of phase IV.

Some interesting findings are contained in the tables of error densities. There are only 16 occasions in which the density of a given error type increased following baseline or termination of consequation out of 390 possible occurrences. In Table 6, Denise made more spelling errors in phase II than she did in phase I. This can be seen by comparing the density figures in rows one and two of column one. If phase VI is eliminated from consideration due to its unusual contingency shift, subjects increased the density of a given error over that present in a noncontingency phase in only a very few cases. Such nonperseveration of errors in writing is not characteristic of deaf children and will be discussed further.

The tables also show that there are only 15 occasions where a subject failed to eliminate a given error in his writing during one of the four phases of the experiment in which consequation was in force. It was possible for such an event to occur 520 times during the course of the experiment. This indicates that considerable control was established over the various sorts of errors committed by subjects. Further, the effect of remediation was quite strong. On only 34 occasions of a possible 390 did the error density for a given type fail to decrease when remediation was in force. Finally, the density of an error type decreased when consequation was terminated during phase IV only 20 times out

of a possible 130 occasions for such an event. It is also interesting to note that if differences in density figures of only 0.02 or greater are considered, the degree of control over accurate composition increases.

Table 4

Error Density by Type per Phase for Barbara

Phase	Error Type												
	Spelling	Word Order	Verb Error	Inc/Spl Sentence	Omission	Insertion	Plural	Singular	Wrong Word	Article Error	Preposition	Adverb	Partitive
I	0.00	0.00	0.33	0.33	2.67	0.00	3.00	0.67	1.33	1.00	0.67	1.00	0.00
II	0.22	0.00	0.00	0.00	0.67	0.00	1.00	0.22	0.67	0.67	0.11	0.00	0.00
III	0.00	0.00	0.25	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.00	0.00
IV	0.60	0.00	0.60	0.20	1.40	0.20	0.40	0.80	0.40	0.40	0.00	0.00	0.00
V	0.20	0.00	0.00	0.00	0.20	0.00	0.20	0.20	0.00	0.60	0.00	0.00	0.00
VI	0.20	0.20	0.40	0.00	0.20	0.60	0.00	0.20	0.80	0.20	0.00	0.00	0.00

Table 5

Error Density by Type per Phase for David

Phase	Error Type												
	Spelling	Word Order	Verb Error	Inc/Spl Sentence	Omission	Insertion	Plural	Singular	Wrong Word	Article Error	Preposition	Adverb	Partitive
I	0.67	0.33	1.33	0.00	3.67	0.67	1.00	1.00	2.00	2.33	0.33	0.00	0.00
II	0.15	0.08	0.31	0.00	1.08	0.46	0.46	0.77	1.54	0.23	0.08	0.08	0.00
III	0.33	0.00	0.00	0.00	0.55	0.00	0.11	0.11	0.11	0.33	0.00	0.00	0.00
IV	0.20	0.40	2.40	0.80	2.00	0.20	1.60	1.80	1.40	0.20	0.60	0.60	0.00
V	0.20	0.00	0.00	0.00	0.20	0.00	0.00	0.20	0.20	0.00	0.00	0.00	0.00
VI	0.00	0.40	1.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 6

Error Density by Type per Phase for Denise

Phase	Error Type												
	Spelling	Word Order	Verb Error	Inc/Spl Sentence	Omission	Insertion	Plural	Singular	Wrong Word	Article Error	Preposition	Adverb	Partitive
I	0.25	0.25	6.00	0.75	2.75	1.00	0.75	1.00	1.50	1.75	0.75	0.25	0.00
II	0.38	0.15	0.31	0.00	0.77	0.31	0.23	0.69	0.69	0.31	0.08	0.00	0.00
III	0.11	0.00	0.66	0.00	0.88	0.33	0.33	0.44	0.11	1.33	0.33	0.55	0.00
IV	0.60	1.80	1.60	0.40	2.60	0.20	0.20	1.80	1.80	1.00	1.80	0.00	0.20
V	0.00	0.25	0.00	0.00	0.25	0.00	0.00	0.50	1.00	0.00	0.25	0.00	0.00
VI	0.00	0.00	1.60	0.20	0.40	0.40	0.20	0.20	0.40	0.00	0.20	0.00	0.00

Table 7

Error Density by Type per Phase for Lorna

Phase	Error Type												
	Spelling	Word Order	Verb Error	Inc/Spl Sentence	Omission	Insertion	Plural	Singular	Wrong Word	Article Error	Preposition	Adverb	Partitive
I	0.00	0.00	3.00	0.00	0.75	0.25	0.25	1.25	0.75	2.25	0.00	0.25	0.00
II	0.23	0.00	0.23	0.00	0.85	0.08	0.38	0.31	0.61	0.46	0.15	0.00	0.00
III	0.22	0.22	0.22	0.11	0.11	0.33	0.00	0.22	0.00	0.44	0.00	0.00	0.00
IV	0.20	0.80	0.20	0.00	1.40	0.80	0.00	0.40	1.40	0.20	0.20	0.20	0.00
V	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.20	0.00	0.20	0.00	0.00	0.00
VI	0.00	0.00	0.20	0.00	0.40	0.00	0.00	0.40	0.40	0.80	0.40	0.20	0.20

Table 8

Error Density by Type per Phase for Maurice

Phase	Error Type												
	Spelling	Word Order	Verb Error	Inc/Spl Sentence	Omission	Insertion	Plural	Singular	Wrong Word	Article Error	Preposition	Adverb	Partitive
I	0.00	0.67	2.33	0.00	4.67	1.33	0.33	0.00	1.00	0.00	2.00	0.00	0.00
II	0.44	0.00	0.88	0.55	2.77	0.22	0.11	0.55	0.99	1.33	0.33	0.00	0.00
III	0.44	0.22	0.55	0.00	0.55	0.22	0.11	0.55	0.44	0.44	0.11	0.00	0.00
IV	0.80	0.80	1.20	1.80	3.20	0.40	0.60	0.80	3.00	1.00	0.40	0.00	0.00
V	0.00	0.00	0.00	0.00	0.20	0.00	0.20	0.20	0.00	0.60	0.00	0.00	0.00
VI	0.20	0.80	1.20	0.00	1.00	0.60	0.40	0.40	1.60	0.20	0.40	0.20	0.00

Table 9

Error Density by Type per Phase for Peter

Phase	Error Type												
	Spelling	Word Order	Verb Error	Inc/Spl Sentence	Omission	Insertion	Plural	Singular	Wrong Word	Article Error	Preposition	Adverb	Partitive
I	0.00	0.50	1.75	1.00	0.50	0.50	0.00	0.50	1.00	1.75	0.00	0.00	0.00
II	0.27	0.00	0.01	0.01	0.36	0.01	1.01	0.82	0.55	0.36	0.18	0.00	0.00
III	0.29	0.00	0.00	0.00	0.29	0.14	0.43	0.00	0.00	0.43	0.00	0.00	0.00
IV	0.33	0.00	0.00	0.00	0.00	0.00	1.00	0.33	0.00	1.00	0.00	0.00	0.00
V	0.20	0.20	0.00	0.00	0.00	0.20	0.80	0.40	0.00	0.60	0.00	0.00	0.00
VI	0.20	0.00	0.40	0.00	0.40	0.00	0.00	0.40	0.40	0.20	0.40	0.00	0.00

Table 10

Error Density by Type per Phase for Richard

Phase	Error Type												
	Spelling	Word Order	Verb Error	Inc/Spl Sentence	Omission	Insertion	Plural	Singular	Wrong Word	Article Error	Preposition	Adverb	Partitive
I	0.33	0.33	7.33	0.67	4.33	0.67	0.33	1.33	1.67	0.33	0.33	0.67	0.00
II	0.11	0.00	0.22	0.22	1.44	0.22	0.55	0.55	0.55	1.00	0.00	0.33	0.00
III	0.22	0.11	0.22	0.00	0.66	0.11	0.22	0.33	0.11	0.11	0.00	0.11	0.00
IV	0.60	1.20	3.00	1.00	1.40	0.20	5.60	0.20	0.40	0.40	0.20	0.00	0.00
V	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.20	0.20	0.00	0.00
VI	0.00	0.00	0.20	0.00	0.60	0.00	0.00	0.00	0.00	0.20	0.40	0.20	0.00

Table 11

Error Density by Type per Phase for Scott

Phase	Error Type												
	Spelling	Word Order	Verb Error	Inc/Spl Sentence	Omission	Insertion	Plural	Singular	Wrong Word	Article Error	Preposition	Adverb	Partitive
I	1.00	0.00	2.25	0.00	0.50	0.50	0.50	0.50	0.75	1.25	0.50	0.25	0.00
II	0.58	0.17	0.17	0.08	0.67	0.08	0.83	0.25	0.42	1.16	0.00	0.00	0.00
III	0.62	0.00	0.12	0.00	0.12	0.12	0.25	0.12	0.12	0.25	0.12	0.00	0.00
IV	1.33	0.00	1.33	0.67	1.00	0.00	0.33	0.67	2.33	0.33	0.00	0.33	0.33
V	0.40	0.00	0.00	0.00	1.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VI	0.40	0.20	0.80	0.20	0.00	0.80	0.00	0.20	0.20	0.20	0.00	0.00	0.00

Table 12

Error Density by Type per Phase for Steven

Phase	Error Type												
	Spelling	Word Order	Verb Error	Inc/Spl Sentence	Omission	Insertion	Plural	Singular	Wrong Word	Article Error	Preposition	Adverb	Partitive
I	0.25	0.00	2.00	0.50	2.75	0.50	0.75	0.00	1.25	1.75	1.00	0.25	0.00
II	0.08	0.00	0.00	0.00	0.46	0.00	0.23	0.00	0.46	0.31	0.00	0.00	0.00
III	0.00	0.00	0.00	0.00	0.11	0.00	0.11	0.33	0.11	0.22	0.00	0.00	0.11
IV	0.40	0.20	0.80	0.80	1.00	0.40	1.00	0.40	0.80	2.60	0.00	0.00	0.20
V	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VI	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 13

Error Density by Type per Phase for Susan

Phase	Error Type												
	Spelling	Word Order	Verb Error	Inc/Spl Sentence	Omission	Insertion	Plural	Singular	Wrong Word	Article Error	Preposition	Adverb	Partitive
I	0.50	0.75	2.25	0.25	2.00	1.00	1.25	0.75	1.25	0.75	0.25	0.00	0.00
II	0.15	0.08	0.23	0.00	0.31	0.08	0.77	0.15	0.23	0.77	0.08	0.08	0.00
III	0.20	0.20	0.60	0.00	1.40	0.80	0.40	0.00	0.00	1.00	0.20	0.00	0.00
IV	0.40	0.00	0.80	1.40	0.80	0.20	0.20	1.20	0.60	1.00	0.20	0.20	0.00
V	0.00	0.00	0.00	0.20	0.00	0.00	0.40	0.00	0.00	0.60	0.00	0.00	0.00
VI	0.00	0.00	0.33	0.00	2.00	1.00	1.00	1.33	1.33	0.33	0.00	0.00	0.00

SECTION IV

DISCUSSION

The results of the experiment demonstrate that effective control was established over the behavior of the subjects. The instatement of reinforcement and remediation as consequences for appropriate composition established and maintained high response rates and high levels of accuracy. Modification of contingencies requiring more complex behavior resulted in a more frequent occurrence of higher-order sentence writing. The effects of certain uncontrolled variables on the sentences written by the subjects require elaboration.

During the final session (session 4) of phase I (Baseline) the accuracy with which subjects wrote sentences increased except for one. The events which at least partially determined this improved sentence writing involved visitors who remained in the experimental room throughout the session. David is the son of an Air Force major who completed a year-long tour of duty in Viet Nam and returned home on the Saturday before the Monday of the session in question. Both David's father and mother visited the class for the entire school day. Their presence exerted some control over the quality of David's performance and the performance of other members of the class not only in the experimental session, but during other class activities. Since the rate of sentence writing and the length of those sentences remained stable at this point, the change of contingencies to begin phase II was carried out on the following day.

The American School for the Deaf demonstrates its teaching and other

activities as well as displaying its facilities to numerous visitors virtually each day of the school year. As a result, students at the school acquire certain discriminated operants. Such behaviors involve "behaving well" when visitors are present in the classroom. It is reasonable to assume that this sort of phenomenon operated when David's parents were present.

Mediated Interaction. One interesting feature of the experiment was that the technology used made possible examination of active composition as an operant in conjunction with human rather than mechanical determination of consequences. The MIVR system provides the opportunity to exert precise control over verbal behavior while retaining many of the desirable features of direct interaction between students and a teacher. The reinforcement of sentence writing is virtually immediate when the MIVR system is used, thus eliminating delays between the occurrence of composition or other responses and the presentation of reinforcement and remediation. The gains possible through immediate consequation are clearly shown in the data from the experiment.

The verbal environment present in a classroom of hearing students provides a considerable amount of information to those students in a vicarious manner. A teacher is heard by all students when a response from one student is consequated verbally. The other students can use or not use the information, but this is not the case in classrooms of deaf students. Deaf students work in classrooms which are deprived in verbal content of the sort described. Teachers of the deaf have attempted to develop methods for overcoming this limitation, but are faced with delays in the consequation process as a result. For example, many teachers

of the deaf have students all write stories on chalkboards and then will correct each composition for the class as a whole when the students have returned to their seats. The effectiveness of this procedure is lost by the delay between the behavior and its consequence. In the experiment, an example of how the MIVR system overcomes such limitations in procedures for deaf classrooms occurred in the sixth phase.

The contingency for compound and complex sentence writing was established on the first session of the phase. Subjects continued producing simple sentences but increased the number of modifiers used during the session. About halfway through the session, Maurice attempted the composition of compound sentences on three trials. Errors were remediated, and on the fourth attempt the response was grammatically correct and two points were administered. The other subjects watched this happen and began writing compound sentences. The error rates were fairly high, but by the second session of the phase all subjects had successfully produced several compound sentences. The same sort of process occurred in later sessions with several different types of complex sentences as well.

Throughout the experiment, subjects attended to each other's responses, the errors produced, and the remediation which resulted. One subject, David, during phases III, V, and VI provided remediation to other subjects in addition to that provided by the experimenter. That is, he would point out errors to others and would, when possible, show a similar error that had occurred previously and how it had been remediated. This behavior on the part of David was

unusual in consideration of his teacher's description of his general performance in school prior to the start of the experiment. David had demonstrated a reluctance to engage in such task leadership since entering school the previous September according to his teacher. The classroom environment used in the experiment seemed to foster more involvement on David's part in the activities of the class.

It is unlikely that the sort of operations performed and the type of behavior generated in the experiment could have occurred without the use of the sort of equipment in the MIVR system. Other techniques for providing immediate consequation are certainly available, but the access to complex forms of verbal behavior and the ability to use the capabilities of a teacher depend on the sort of visibility and explicitness of responses and consequences possible with the MIVR system.

Verbal Behavior. Generation of higher densities of autoclitic behavior in subjects was of principal concern in the experiment. Of the thirteen categories of error types generated in the data, only two, spelling and verb errors, were not directly autoclitic in nature. Although autoclitic density per sentence decreased with the reduction of sentence length, each sentence necessarily contained autoclitics. The very high levels of accuracy maintained by the consequences available in phases II, III, V, and VI of the experiment and the high rate of sentence writing in these phases indicated that autoclitic density and accurate usage increased considerably in the behavior of each subject. Samples of correct and incorrect sentences written by each subject are contained in Appendix 2.

The data concerning types of errors show that incorrect autoclitic responses, as were the other two categories, were virtually eliminated from the subject's behavior. Effects of this control over responses presented themselves outside the experimental sessions. The classroom teacher of the subjects reported a marked decrease in the frequency of errors made by her students in their written work in the classroom. This was particularly true of Scott, David, Maurice and Richard. Each student in the class composed a letter to his parents each week. Prior to the experiment, the four subjects mentioned wrote particularly inaccurate letters. By the last four weeks of the experiment a considerable improvement in the accuracy of the letters could be seen. In particular, David and Scott produced at least one errorless letter without special prompting from the teacher. In addition, whereas David had rarely spoken orally without a direct request to do so from the teacher prior to the start of the experiment, the frequency of nonprompted oral responses increased noticeably throughout the duration of the experiment.

The changes in the adequacy of composition by subjects within the experimental setting and the reported changes which occurred in other educational settings supports the general conclusion that the manipulated variables established and maintained control of accurate composition. The magnitude of changes from baseline accuracy in phases II, III, V, and VI was large for all subjects. The rate of sentence writing attained by the group as a whole in phases where consequation occurred was quite high and steady. The expectations for the performance of deaf students at the age of the subjects which are held by many teachers of the

deaf were far exceeded. Silverman, Lane, and Doehring (1964) report that

> "The rate of progress for deaf children varies from the norms of hearing children. For example, it takes a deaf child approximately two years to complete the second grade and one and a half years to cover third-grade material (p.427)."

The results of the experiment contrast sharply with other findings regarding the rate at which deaf children acquire skills.

Implications for Research. One important area to be explored in further analyses of composition by deaf children is that of producing self-control of behavior developed through use of procedures such as those used in the experiment. The process of self-control is one in which the student's behavior is maintained without the frequent occurrence of external consequences over long periods of time. Continuous reinforcement maintains behavior which is readily extinguished following the withdrawal of reinforcement. The generation of behavior which is highly resistant to extinction is important to the teaching process. In the case of deaf children, the development of adequate language skills depends on training students to discriminate correct from incorrect language usage and to produce accurate language. Only when a student finds his behavior successful can self-control of behavior operate. The occurrence of "successful" behavior must be paired with salient consequences in the environment in order for that behavior to gain strength as a reinforcer for its emission. Lovaas (1969) demonstrates how the emission of adequate verbal behavior can be established as a reinforcer for a child. In an intensive analysis of psychotic children who responded to

social contact by other humans with rage, anxiety, or withdrawal, Lovaas developed a program in which social contacts were paired with the availability of food. Non-emotional responses were consequated. By placing the child on a schedule of intermittant reinforcement for non-disruptive, non-emotional responses to social contact, the occurrence of social contacts gained strength as a reinforcer for verbal behavior from the student. By carefully reducing the number of primary reinforcers used to maintain the childrens' behavior, the social contact ultimately controlled the behavior without the necessity of presenting food. Skinner calls this process "stretching the ratio" (1968, p. 158f).

Since deaf students typically function in an impoverished verbal environment, composing a sentence that comes out right need not automatically reinforce the process of composition. Training deaf students to discriminate their behavior as correct or incorrect through the use of external reinforcers and then stretching the ratio can lead to strengthening being correct as a self-reinforcing event. It would have been interesting to extend phase VI over a long period and employ an increasing variable ratio schedule of reinforcement to produce self-maintenance. Of importance would be not only the accuracy and rate of responses in an experimental setting, but the changes which might be seen in composition in other settings, particularly those outside the educational environment.

The subjects used in the experiment were classified as "bright" and as "high achievers" by their school and teacher. It would be informative if other groups of students labeled as "dull" and "low achievers" were used as subjects

in a similar experiment. Through careful contingency management it is conceivable that such students, and students of different ages, could produce rates of accurate composition similar to those obtained. An interesting finding in the data was that no differentiation of subjects' performance was possible on the basis of whether they were male or female, day or resident students, had hearing or deaf parents, or whether they had hearing or deaf siblings. Achievement differences have been noted on such dimensions (Myklebust, 1964). The only clear difference in performance in the experiment was on the basis of amount of hearing loss, which is not surprizing.

The examination of other operants than composition through procedures used in the experiment would be worthwhile. By adapting available programmed material (cf. Wooden and Willard, 1965) for use with procedures of contingency management, concomitant manipulation of content-oriented responses and composition could be undertaken. Content-oriented operants could be manipulated independently as well in order to provide additional information on the education of deaf children.

Sufficient evidence was presented in the data from the experiment to generate an extensive series of related questions and series of investigations into a broad range of variables effecting the education of deaf children.

Other Considerations. The use of remediation is an effective means for generating directed change in the behavior of individuals. The type of remediation used in the experiment was limited in order to maintain uniformity of consequation. Demonstrations using more extended forms of remediation in

programming college courses have been made. In two such demonstrations (Michael, 1968b; Ulrich, 1968a) remediation was accomplished through use of a large number of teaching assistants. The assistants served as proctors for students and provided individually designed directions to material which would provide students with information necessary to improving their performance in the course. In both of these demonstrations, the educational gains realized through extensive individualization of the instructional process required heavy expenditures of manpower and time. This does not necessarily argue against the process of remediation as a desirable feature in classroom instruction. The technology necessary for effective remediation of inaccurate behavior in the classroom simply needs to be adapted and utilized.

A process which may operate in deaf classrooms and schools to generate relatively low rates of acquisition of skills and abilities involves the expectations held by teachers of the deaf toward the abilities of their students. While in training, teachers of the deaf receive presentations of information concerning the academic achievement of deaf children based on findings such as those of Fusfeld (1955) and Wrightson, Aronow, and Moskowitz (1962). Such information might presumably lead teachers to form expectations of slow progress and low achievement for their students. The manner in which the teacher presents material to students and the nature of the material would be determined by those expectations in part. When students do in fact work at a slow pace on low-level material, the teacher's expectations are confirmed. A cycle of self-fulfilling prophesies is then formed. The effect of information on the expectancies held

by individuals has been examined by Walster and Aaronson (1967). Affective regard of a task changes with the type of information that individuals receive about that task.

Training teachers to use procedures and technology similar to that used in the experiment might result in the generation of expectations for the performance of deaf children which are greater than those previously held. That is, the results of the experiment suggest that contingencies can be established and procedures developed which lead to the establishment and maintenance of sustained high output from deaf children. This interpretation of the widespread low achievement by deaf children is tentative and requires further data, but is suggestive of possible ways to foster greater effectiveness in deaf education than is now the case.

Many of the objections made to the application of behavior modification procedures to use in the classroom (discussed in section I) are concerned with the problem of identifying appropriate or suitable ends for the powerful means to be used. This problem of choosing the objectives for a child's learning exists in every educational setting including those which leave the choice to the children. Although the variables manipulated in this experiment were limited, the effects on behavior were strong. In those cases where some agreement can be reached regarding the objectives of educational activities, the procedures and techniques which are included in the operant or behavior modification approach would insure reaching those objectives.

The process of "labeling" children as "slow," "retarded," "low-achieving,"

or with other similar terms may serve to restrict the range of their potential accomplishments in schools and elsewhere if such labels are misused. Such limitations do not lead to effective and efficient functioning in classrooms. By treating students as if they were not a priori limited in the amount or rate of achievement possible, a teacher could concentrate on what each student can do and then modify or shape his behavior to meet desired objectives. The approach to changing human behavior taken in this experiment can provide teachers with the means to escape from limited expectations and inefficient or inappropriate methods for improving the intellectual capabilities of their students.

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APPENDIX I

Number of Sentences--Correct and Total--Written per Session by Each Subject

Session	Barbara	David	Denise	Lorna	Maurice	Peter	Richard	Scott	Steven	Susan
1	10/16	8/16	7/16	9/16	9/16	11/16	4/16	6/16	5/16	10/16
2	14/31	--/--	7/13	20/31	16/31	17/30	15/31	25/31	11/24	20/33
3	21/27	10/27	12/27	17/27	8/17	19/27	14/27	22/27	18/27	16/27
4	--/--	23/30	10/29	22/30	--/--	25/30	--/--	20/30	19/30	19/30
5	--/--	27/33	28/35	30/33	--/--	30/33	--/--	29/33	32/33	30/33
6	--/--	28/40	33/40	38/41	--/--	34/40	--/--	36/40	40/40	35/40
7	--/--	33/42	37/42	36/42	--/--	37/42	--/--	41/42	42/42	40/42
8	--/--	35/40	37/40	36/40	--/--	37/40	--/--	33/40	39/40	35/40
9	27/36	30/36	27/36	26/36	14/36	33/36	26/36	32/36	30/36	31/36
10	35/38	33/38	37/38	33/38	35/38	29/38	30/38	32/38	35/38	33/38
11	39/42	36/42	39/42	42/42	35/42	--/--	41/42	41/42	42/42	40/42
12	36/38	35/38	34/38	38/38	33/38	--/--	36/38	29/36	37/38	35/38
13	4/4	38/40	39/40	39/40	35/40	37/40	35/40	37/40	38/40	40/40
14	40/48	44/48	47/48	46/48	46/48	43/48	42/48	--/--	47/48	47/48
15	55/56	54/56	54/56	56/56	48/56	55/56	56/56	52/56	55/56	55/56
16	41/42	51/51	48/51	48/51	47/51	48/51	47/51	48/51	51/51	49/51
17	44/45	43/45	44/45	45/45	45/45	45/45	41/45	41/45	45/45	42/45
18	--/--	35/37	35/37	34/37	34/37	36/37	36/37	35/37	36/37	33/37

APPENDIX I (cont.)

Session	Barbara	David	Denise	Lorna	Maurice	Peter	Richard	Scott	Steven	Susan
19	--/--	39/40	34/40	32/35	35/40	38/40	39/40	--/--	40/40	34/40
20	--/--	39/41	36/41	38/41	36/41	--/--	38/41	37/41	40/41	39/41
21	--/--	23/37	20/37	36/37	17/27	--/--	23/37	25/27	25/27	14/16
22	--/--	43/43	39/43	42/43	40/43	40/43	41/43	41/43	42/43	--/--
23	39/40	39/40	37/40	40/40	38/40	39/40	38/40	39/40	39/40	--/--
24	45/46	46/46	43/46	45/46	45/46	45/46	46/46	46/46	45/46	--/--
25	35/35	33/35	30/35	33/35	31/35	34/35	33/35	35/35	34/35	--/--
26	28/30	28/30	27/30	28/30	28/30	30/30	28/30	28/30	30/30	25/30
27	38/38	32/42	27/42	39/42	24/42	41/42	38/42	26/42	33/42	33/42
28	37/40	25/40	23/40	39/40	30/40	35/40	10/16	38/40	31/40	34/40
29	46/48	28/46	32/48	43/48	45/47	38/48	45/41	--/--	33/43	42/45
30	40/47	43/47	36/47	36/47	29/47	--/--	26/47	40/47	43/47	40/47
31	34/48	42/48	42/53	40/48	41/52	--/--	22/52	--/--	33/46	36/48
32	31/32	31/32	--/--	32/32	30/32	29/32	32/32	29/32	32/32	31/32
33	37/41	41/41	39/41	41/41	41/41	39/41	41/41	41/41	41/41	39/41
34	57/57	57/57	54/57	56/57	56/57	54/57	56/57	57/57	57/57	56/57
35	56/56	54/56	55/56	56/56	56/56	55/56	54/56	55/56	56/56	56/56
36	49/51	50/51	48/51	49/51	48/51	50/51	51/51	47/51	51/51	50/51
37	11/13	12/13	7/13	12/13	7/13	12/13	10/13	7/11	13/13	--/--
38	16/19	17/19	16/19	16/19	13/19	15/19	18/18	14/19	19/19	10/16

APPENDIX I (cont.)

Session	Barbara	David	Denise	Lorna	Maurice	Peter	Richard	Scott	Steven	Susan
39	15/18	16/18	14/18	14/18	12/18	16/18	17/18	17/18	18/18	11/18
40	18/20	19/20	15/20	16/20	12/20	19/20	18/20	18/20	20/20	15/17
41	20/22	21/22	22/22	21/22	19/22	20/22	20/22	21/22	22/22	--/--

APPENDIX II

Samples of Correct and Incorrect Sentences Written by Subjects

Two correct (C) and two incorrect (I) sentences written in each of the six experimental phases are listed for each of the ten subjects. These samples were drawn from the raw data and reflect the changes which occurred in the writing of the subjects throughout the course of the experiment. Since the number of incorrect sentences decreased markedly in phases where reinforcement was available, the samples are weighted incorrectly. However, the types of errors are interesting and are presented in equal numbers to correct sentences.

Phase I (Baseline)

Barbara	(C)	A man is standing in front of a white car.
		The store is big.
	(I)	A dog lost its collar from a boy.
		The store has lots of food for us and people.
David	(C)	The drug store is rather big.
		A ball is under the chair.
	(I)	Some flowers is rather large.
		A boy liked to ride bike.
Denise	(C)	Some fruit is on the table.
		A boy sat down on the floor and watched TV.
	(I)	A dog is lost collar without a boy.
		The drug store have many pills for family.

Lorna	(C)	His mother was mad.
		The fruit was on the table.
	(I)	My father bought some newspaper last week.
		A girl liked to carry a doll kitten.
Maurice	(C)	The kitten was cute.
		The drug store is new.
	(I)	The dog will lost.
		The rather fruit are good.
Peter	(C)	A flea hopped out of the box.
		A mischievous girl put a cat in the doll buggy.
	(I)	5¢ and 10¢ store has toys inside it.
		A food store is really ENORMOUS.
Richard	(C)	The store is rather small.
		A man took the car.
	(I)	A girl carry kitten on their hand.
		The table were white paper.
Scott	(C)	A cute puppy is under the wooden table.
		We went to Tilley's store.
	(I)	A girl is holing an ice-cream and she hold a book and read it.
		A ball has a white band on it uner a chair.
Steven	(C)	The store is rather small.
		A ball is under a chair.

Steven (cont.)	(I)	There has many books in Tilley's magazine newspapers.
		A teacher told to the boy "Pick it up the box."
Susan	(C)	The table is very clean.
		My mother goes to the store every Thursday.
	(I)	The fruit & Vegatable is looks like a tent.
		A little boy is sitting closely to the TV.

Phase II (Reinforcement)

Barbara	(C)	Milk is good for us to drink.
		There is a tube of toothpaste.
	(I)	There is a box of bacons.
		The rain pour down from the clouds.
David	(C)	There is a bottle of milk.
		The box is square.
	(I)	The weather is raining.
		I see a toothpaste.
Denise	(C)	We can see it on the table.
		There is an empty pail.
	(I)	There is a milk.
		There were some bread.
Lorna	(C)	There is a bottle of milk.
		There is a can.
	(I)	There is an small airplane.
		There are some bread.

Maurice	(C)	It is raining today.
		The airplane flew away.
	(I)	The bread dropped it.
		The bottle milk is too heavy.
Peter	(C)	There is a gallon of milk.
		I see some eandy eanes.
	(I)	A bunch of grapes are ripe.
		I like to eat some bacons.
Richard	(C)	I ean see a man.
		There is a basket.
	(I)	We ean see many candy.
		There were lot of rain.
Seott	(C)	There is a small peneil.
		It is good to eat.
	(I)	A man is looking at each other.
		There is an great airplane.
Steven	(C)	There is a strawberry.
		The apple is big.
	(I)	There is a pieee of grape.
		There is a loaf of breads.
Susan	(C)	There is an old man.
		There is an empty basket.

Susan (cont.)	(I)	There are some bread.
		There is a juice.

Phase III (Reinforcement plus Remediation)

Barbara	(C)	I can see a comb on the leaf.
		I can see some children laughing at each other.
	(I)	One cow is lying on a grass.
		There is a station wagon car.
David	(C)	I see some fish in the water.
		I see some dogs.
	(I)	I see cow on the ground.
		I see window.
Denise	(C)	There is a boy walking across the bridge.
		There is a boy laughing at the teacher.
	(I)	One of the cake is gone on the plate.
		There is a girl talking another girl.
Lorna	(C)	I see a boy drinking some water.
		I see three mountains.
	(I)	A girl is liking a doll.
		The woman was scold at a little girl.
Maurice	(C)	The chair is near the window.
		The watch is not big.
	(I)	The trees is near the town.
		There is a dog playing a ball.

Peter	(C)	The children laughed.
		I see some baby chicks.
	(I)	The truck can carry many mails.
		The tires are for an automoblic.
Richard	(C)	There are some children.
		I see a cute kitten.
	(I)	I see coffee pot.
		I see a baby with ball.
Scott	(C)	There is a big cat.
		There is a good boy.
	(I)	There is a best car.
		There is an emty can.
Steven	(C)	I can see an owl.
		Some children are talking.
	(I)	There is a piece of pencil.
		A boy is good in a school.
Susan	(C)	There is a police car.
		The caveman ran into the cave.
	(I)	The car has a stagewagon.
		I see a boy lawning a mower.

Phase IV (No Consequation)

Barbara	(C)	There were some children.
		I can see many stars.

Barbara (cont.)	(I)	I can see superhigway.
		I can see some balloon.
David	(C)	I see three chairs.
		I see them.
	(I)	Denise her dress is tearing her book.
		I see Denise's face of stamp.
Denise	(C)	There is a man.
		There were many people.
	(I)	I do not know who was he?
		There were two train.
Lorna	(C)	I see a man.
		There is another train.
	(I)	I see large dining-room.
		I see beautiful bedroom.
Maurice	(C)	I see two trains.
		I see many highways.
	(I)	I see a longer trains.
		I see a ant clock.
Peter	(C)	People sleep in the train.
		Stars don't have five points.
	(I)	There is a tallest mountain.
		There is a flat train.

Richard	(C)	I see it.
		I see it on the ground.
	(I)	One fish is die this day.
		The many people wait for Denise to vote.
Scott	(C)	There are two children.
		There is a policeman standing there.
	(I)	There is the best car that I want.
		Denise need glasses and Barbara, too.
Steven	(C)	There are some cans.
		I see some mountains.
	(I)	A football is a game.
		There are a great dolls.
Susan	(C)	I can see Richard on the train.
		There is a beautiful Christmas tree.
	(I)	I can see ghost clock.
		There is a box of Barbara!

Phase V (Reinforcement plus Remediation)

Barbara	(C)	There is a bunch of bananas.
		I can see an airplane.
	(I)	There is a meat.
		There are many mountians.
David	(C)	I can see the hammer on the ground.
		The boy is cutting the paper.

David (cont.)	(I)	I see a nut girl.
		The boy is wet his shoes.
Denise	(C)	There is a hammer on my desk.
		There is a big girl being helpful.
	(I)	There is a big boy helpful.
		There is a baby girl playing her ball.
Lorna	(C)	I see a pair of shoes on the floor.
		I see a boy writing a paper.
	(I)	The girl is comb her hair.
		I see a awful flower.
Maurice	(C)	There is the comb.
		I see a man running.
	(I)	I see a bread.
		I see a butter near the knife.
Peter	(C)	I see an apple in a bowl.
		Jerry is sad.
	(I)	I see a largest mountain.
		The family are going to a movie.
Richard	(C)	I see a book on the chair.
		I see many cities.
	(I)	There is a glue.
		I can see it on floor.

Scott	(C)	There are some hot dogs.
		I like grapes.
	(I)	There is an plant.
		Some people went to store.
Steven	(C)	There is a pair of shoes.
		I see them on the bed.
	(I)	(No Errors)
Susan	(C)	There are some carrots.
		There is a car.
	(I)	There is a meat.
		I see 11,427 ft.

Phase VI (Reinforcement plus Remediation for Higher-order Sentence Writing)

Barbara	(C)	There is a kitten who has big round eyes.
		There is a girl who is lost in the woods.
	(I)	There is a girl who always smiling.
		There are two girls who is jumping high.
David	(C)	There is a girl who stole a hat.
		There is a woman who found some pretty flowers.
	(I)	There is a shark who stole a boy.
		There is a clown standing on the sidewalk and said
		"Goodby."
Denise	(C)	There were two girls talking and jumping.
		There is a man walking on the street.

Denise (cont.)	(I)	There were two men talking and his friend holding his hose over the window.
		There were two kites flying up the sky.
Lorna	(C)	I see a girl jumping on the road.
		I see a girl holding a cute cat.
	(I)	I see a cute cat watching a mice.
		I see a man's face who is saw a man's nose.
Maurice	(C)	The baby is crying because he wanted to play with the toy bear.
		There is a bag of potatoes.
	(I)	The dog is big and the dog is little.
		The girl is sleepy because she was working from the room.
Peter	(C)	The baby had slept for one hour.
		A boy is sleeping on the hammock.
	(I)	A car can go from street to another street.
		A older boy is waiting for his school.
Richard	(C)	I see a baby sitting on the bed.
		I see a boy standing on the floor.
	(I)	I see a tree sitting on the ground.
		I see a woman holding dropping two toy hands.
Scott	(C)	There is a boy standing there doing nothing.
		There is a girl she likes.

Scott (cont.)	(I)	There are some boats who found them.
		There are two wood that Richard wanted.
Steven	(C)	There is a clown sitting on the chair.
		There is a man who saw some trees.
	(I)	(No Errors)
Susan	(C)	There are two girls who hold the cats.
		There are the clowns who are so funny.
	(I)	There are two clown who always silly.
		There is a boy who looked the number.