

The University of Manitoba

EFFECTS OF INTERLOCKING AND FIXED-RATIO
SCHEDULES OF REINFORCEMENT ON
PICTURE-NAMING BEHAVIOR OF RETARDED CHILDREN

by

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ABSTRACT

Picture-naming behavior of two retarded children was reinforced according to two schedules of reinforcement. In one experimental condition a fixed-ratio schedule of reinforcement was in effect in which reinforcement occurred after a fixed number of correct responses. In a second experimental condition an interlocking schedule of reinforcement was in effect. The interlocking schedule was identical to the fixed-ratio schedule except that the number of correct responses required for reinforcement increased with the passage of time since the previous reinforcement. Both subjects spent less time engaging in inattentive behavior, emitted more correct responses, and learned more words in the condition in which the interlocking schedule of reinforcement was in effect. In addition, one of the subjects made fewer errors in this condition. This difference in performance might have been due to the fact that reinforcement occurred more frequently in the fixed-ratio condition than in the interlocking condition. Thus, the requirement of the fixed-ratio schedule of reinforcement was increased so that the subjects emitted approximately the same number of responses per reinforcement under both schedules of reinforcement. With respect to the above mentioned variables, the performance of both subjects remained generally superior in the interlocking condition.

When the requirement of the interlocking schedule of reinforcement was increased, the picture-naming behavior of one subject was enhanced while the picture-naming behavior of the other subject deteriorated.

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CHAPTER I

INTRODUCTION

Events or stimuli which increase the future probability of behaviors which they follow are called reinforcers (Ferster & Skinner, 1957). If the appearance of a stimulus as a consequence of a response results in an increased probability that the response will reoccur in the future, the stimulus is called a positive reinforcer. If the disappearance of a stimulus as a consequence of a response results in an increased probability that the response will reoccur in the future, the stimulus is called a negative reinforcer. Many events which function as reinforcers are related to biological processes important to the survival of the organism (e. g. food, water). In addition to such primary reinforcers, previously neutral events can acquire the status of reinforcers by being paired with the presentation of reinforcers. These types of reinforcers are called conditioned reinforcers. A generalized reinforcer (e. g. attention, money) is a conditioned reinforcer which has been associated with more than one type of primary reinforcer. An extensive body of literature exists describing the application of primary and conditioned reinforcers to produce and maintain a wide variety of behaviors in both animals and humans.

Much research on reinforcement principles has been conducted with children, both normal and retarded, and most commonly has involved the presentation of positive reinforcers. Bijou and Baer (1966) have described a number of positive and negative reinforcers suitable for research with children. Since the present research involved the presentation of positive reinforcers, only those studies in which positive reinforcement was used will be referred to. One type of positive reinforcer has been classified as consumable. (Bijou and Sturges, 1958). Consumables include all varieties of candies (M & M's, Smarties) other types of food (meats, raisins, nuts), and some types of liquids. There are a number of studies in which consumables have been used as reinforcers. For example, Treffry, Martin, Samels and Watson (1970) used candies as reinforcers to shape grooming behaviors in 11 severely retarded girls. The grooming tasks were broken into a number of successive steps. Initially a candy was presented upon completion of only the first step. Gradually the requirement was increased until a candy was presented only after all the steps had been completed. Another class of frequently used reinforcers may be classified as manipulables. Such reinforcers include trinkets, toys, pictures etc. Lovaas (1961) used trinkets as reinforcers to produce and maintain both verbal and non-verbal behaviors in young children. The trinket was kept in a transparent box

during the task and the box was opened after an appropriate number of responses. A third type of reinforcer frequently used is social reinforcement (e.g. approval, attention). Brackbill (1958) reinforced smiling in a 4 month old infant with attention. Contingent on smiling the experimenter picked up the child and smiled and talked to him for 30 seconds. The frequency of smiling was shown to be under the control of the experimenter's attention.

As aspect of reinforcement, the importance of which cannot be overestimated, is the schedule according to which reinforcers are delivered. A schedule of reinforcement is a prescription for initiating and terminating reinforcing stimuli in relation to some behavior (Morse, 1966). More generally, a schedule of reinforcement specifies which instance of a behavior will be reinforced. Schedules of reinforcement have orderly and profound effects on the frequency of occurrence of behavior. Each different schedule of reinforcement produces a characteristic performance. The regularity, stability and rate of occurrence of behavior depend in large part on the schedule of reinforcement in effect. Schedules of reinforcement can be divided into two basic types: those that reinforce a response on the basis of time (interval schedules), and those that reinforce a response on the basis of number of responses (ratio schedules). Interval and ratio schedules

may also be subdivided into two basic types, fixed and variable.

On a fixed-interval (FI) schedule of reinforcement, the first response after a fixed period of time is reinforced. On a variable-interval (VI) schedule of reinforcement, the first response after a varying period of time is reinforced. On a fixed-ratio (FR) schedule of reinforcement, reinforcement is delivered after a fixed number of responses have been emitted. On a variable-ratio (VR) schedule of reinforcement, reinforcement is delivered after a varying number of responses have been emitted. These four schedules comprise the simplest intermittent schedules of reinforcement. Each of these schedules generates a characteristic type of performance. For example, a fixed-ratio schedule of reinforcement characteristically generates a high rate of responding with a pause in responding immediately after reinforcement. A variable interval schedule of reinforcement typically generates an intermediate rate of responding with infrequent pauses. Ferster and Skinner (1957) have described in detail the typical performance of rats and pigeons under different values of these four schedules and under a number of other schedules of reinforcement which are essentially variations and combinations of these simple schedules.

There is a considerable body of evidence that suggests that the typical behaviors generated by schedules of reinforcement in other organisms are also generated in humans. Long, Hammond, May, and Campbell (1958) reinforced lever pressing behavior of a group of 200 children ranging in age from 4 to 8 years. Lever pressing was reinforced alternately according to a variable-interval schedule of reinforcement, a fixed-interval schedule of reinforcement, and a fixed-ratio schedule of reinforcement. The value of the interval of the VI schedule was varied from an average of .5 minutes to 1 minute. The interval of the FI schedule was varied from .5 minutes to 3 minutes and the value of the ratio of the FR schedule was varied from 5 responses to 150 responses. They found that the behavior typically generated in the children by these schedules of reinforcement closely resembled the behavior generated in lower organisms by similar schedules of reinforcement. The only exceptions noted were with respect to the fixed-interval schedule of reinforcement. Typically in lower organisms FI schedules produce "scalloped" rates of responding; a low rate immediately subsequent to reinforcement with a gradually increasing rate of responding as the time for the next reinforcement approaches. Long, Hammond, May, and Campbell (1958) observed such scallops only infrequently and a few subjects never did develop an orderly pattern of behavior under the FI schedule of reinforcement.

In a similar study Ellis, Barnett, and Pryer (1960) examined the rate of lever pressing of 12 adult and 26 teenage retardates. M & M's and cigarettes were used as reinforcers and were presented according to a variable-interval, a fixed-interval, and a fixed-ratio schedule of reinforcement. They also found that the typical behaviors generated by the schedules of reinforcement were very similar to the behavior generated by these schedules in lower organisms. Orlando and Bijou (1960) examined the effects of six schedules of reinforcement on the lever pressing behavior of 46 retarded children ranging in age from 1 to 16 years. They also found that the effects of the schedules of reinforcement on humans resembled closely the effects of the schedules on lower organisms. For example they found that variable-ratio schedules of reinforcement generated high rates of response with infrequent pauses, fixed-ratio schedules produced high rates of response with post-reinforcement pauses, and variable-interval schedules produced steady intermediate rates of response. These schedule effects are all typical of those observed in lower organisms. With respect to fixed-interval schedules, they found that scallops occurred only rarely and that generally a low rate of response was produced. In addition they brought lever pressing under the control of two multiple schedules of reinforcement and again found that the behavior generated in humans by these schedules was similar to the behavior generated in animals.

In general then, it would seem that the rate of occurrence of human behavior is largely a function of the kind and value of the schedule of reinforcement in effect at any given time. Thus in many situations where time is of the essence, such as in the education of retarded children, it would seem that certain schedules or reinforcement are preferable to others as a result of the rates of response they typically generate. For example, in a situation where picture-naming behavior is to be reinforced, a schedule of reinforcement which typically generates high rates of response with infrequent pauses would be preferable to a schedule of reinforcement which typically generates low rates of response with frequent pauses. Although the characteristic performance generated by simple schedules of reinforcement is well documented in human subjects, there are a number of complex schedules of reinforcement which have not been examined. Two interesting schedules mentioned by Ferster and Skinner (1957) are adjusting and interlocking schedules of reinforcement. The schedules are similar in that the number of responses required for reinforcement varies as a function of time or some aspect of the organism's performance. An interlocking schedule is one in which the organism is reinforced upon completion of a number of responses, but this number changes during the interval which follows the previous reinforcement. For example, this number might be 100 immediately after a reinforcement but it decreases with time so that 5 minutes after the reinforcement only 10 responses are required.

An adjusting schedule is one in which the value of the ratio is changed in some systematic way after reinforcement as a function of the immediately preceding performance. For example a fixed-ratio might be increased or decreased by a small amount after each reinforcement depending upon the length of the previous post-reinforcement pause. The distinction between the two schedules is that in an adjusting schedule the change in value of the ratio occurs at reinforcement whereas in an interlocking schedule the change in value of the ratio occurs between reinforcements.

If the frequency of occurrence of human behavior is largely a function of the schedule of reinforcement in effect, then it would be desirable to know the effects of all possible schedules of reinforcement on human behavior. However, the effects of some complex schedules of reinforcement, such as interlocking schedules, have not been determined with human subjects, although some data with non-human subjects exists. The effects of one type of interlocking schedule on the lever pressing or rats have been reported. Berryman and Nevin (1962) employed interlocking schedules in which the number of responses required for reinforcement decreased with the passage of time since the previous reinforcement. They varied both the response base (FR) and the time base (FI) of this interlocking schedule. For example, one value of the interlocking schedule was designated as Interlocking 2/36. This means that immediately after a reinforcement

36 responses are required in order to produce the next reinforcement (FR36). But after the passage of 2 minutes time, only 1 response is required to produce reinforcement (FI 2). They found that as the time base (the amount of time before only 1 response was required for reinforcement) was lengthened, the response rate increased. As the response base (number of responses required) increased, the response rate decreased. Powers (1968) examined the same type of interlocking schedules and compared their effects to the effects of conjunctive schedules of reinforcement. (A conjunctive schedule is one in which the requirements of more than one schedule must be met before a response is reinforced.). With respect to interlocking schedules his results were identical to those of Berryman and Nevin (1962).

An interlocking schedule of reinforcement; however, does not necessarily specify that the number of responses required decreases with the passage of time. Another type of interlocking schedule mentioned by Reynolds (1968) is one in which the number of responses required increases as the time since the previous reinforcement increases. For example an FR50 schedule of reinforcement might be in effect immediately after reinforcement, but this ratio increases with time so that 2 minutes after the reinforcement an FR100 schedule is in effect.

Zeiler (1970) reinforced key-pecking of pigeons according to a fixed-ratio schedule of reinforcement with time limits imposed on responding. The pigeons were reinforced provided they completed the ratio within a specified time since the previous reinforcement, or provided they took longer than a specified time to complete the ratio. Failures to meet the time requirements resulted in a brief timeout (a period in which responding had no scheduled effects) and a resetting of the requirement for reinforcement. He found that shorter time criteria resulted in the ratio being completed faster and longer time criteria resulted in the ratio being completed slower. This schedule is different from the interlocking schedule mentioned by Reynolds because the ratio schedule used by Zeiler was reset after each completion of the ratio, whether or not reinforcement had occurred, (Reinforcement followed the completion of the ratio, only if the time requirement had been met). The interlocking schedule mentioned by Reynolds is reset only after the appropriate number of responses have been emitted and reinforcement has occurred. Reynolds mentions that this interlocking schedule would be dangerous in the sense that if the organism did not begin responding at a high enough rate, its behavior might simply extinguish before a reinforcement ever occurred. But it would seem that such a schedule of reinforcement might prove valuable if it could be introduced gradually and the behavior could be closely monitored to ensure that

extinction did not occur. If the subject could be kept in contact with the contingencies of reinforcement prescribed by such a schedule, a reliably high rate with few pauses might occur.

The purpose of this research then, was to compare the effects of an interlocking schedule of reinforcement with the effects of a fixed-ratio schedule of reinforcement on the picture-naming behavior of retarded children. The fixed-ratio schedule of reinforcement prescribed that reinforcement occurs after a fixed number of correct responses. The interlocking schedule of reinforcement was identical to the fixed-ratio schedule of reinforcement except that the number of correct responses required for reinforcement increased with the passage of time since the previous reinforcement.

CHAPTER II

METHOD

Subjects

The subjects were two severely retarded boys at the St. Amant Ward of the St. Vital Hospital, Winnipeg, Canada. The particular children used in this research were chosen for the following reasons:

(1) If prompted they would imitate the verbal responses of the experimenter. For example, if the experimenter pointed to a picture of a ball and said "What's that? A ball," the child would emit the response "ball".

(2) Both children had limited verbal repertoires in the sense that they could not name many objects. Their limited object-naming repertoires in combination with their ability to imitate verbal responses made these children suitable subjects for a picture-naming task.

Sidney was four years old and had been hospitalized for almost two years at the time this research was initiated. He displayed almost no unprompted verbal behavior other than screaming or laughing. He was generally lethargic except for infrequent intervals when he played with other children. Sidney had a long history of refusing to eat his meals. At meal time he

would throw such violent tantrums that it took three people to feed him. As a result of this behavior, the child was introduced into an operant conditioning program approximately four months prior to this experiment. Undesirable behaviors incompatible with eating were extinguished and desirable eating behaviors were shaped through the use of differential reinforcement. The procedure was terminated after $1\frac{1}{2}$ months at which time the child was consistently eating on his own. In addition to the above procedure approximately forty 20-minute sessions were spent training Sidney to sit attentively and to imitate verbal responses.

Bobby was eight years old and had been hospitalized for almost four years. He also displayed very little unprompted verbal behavior although his verbal repertoire was more extensive than that of Sidney. Bobby was extremely active. He continually moved about and stopped only rarely to play with toys or with other children. He had previously been a subject in an experiment investigating the effects of electrical shock as a punisher in a picture-naming task (Kircher, Pear, and Martin, 1971). As a result he was familiar with some aspects of the present procedure.

Apparatus

This research was conducted in a specially constructed operant conditioning research area in the St. Vital Hospital. The cubicle used in this research was approximately 8 feet x 10 feet and contained a low counter along one wall, a low child-sized table, three chairs, and a Lehigh Valley Electronics Modular Human Intelligence System (# 520-02). A one-way mirror and a small hole through which power cables could be passed were located in the wall between the experimental room and an adjacent equipment room. A subject was seated behind the table opposite the experimenter. The table was placed with one edge adjacent to the counter such that when the subject was seated the counter was positioned to his immediate left. The Human Intelligence System was situated on this counter within easy reach of the subject.

The Human Intelligence System consisted of six snap-on panels of which only three were operative during experimental sessions. The three operative panels were a candy dispenser panel, a stimulus array panel and a lever panel. These panels were joined by cables to a connection panel in the adjacent equipment room in which the programming equipment was housed. Initially Lehigh Valley Electronics electromechanical programming equipment was used but this was later replaced with a programmable digital logic system built to specification by DRT Associates (Winnipeg, Canada). The operation

of this equipment was silent except for a series of electro-mechanical counters. Two small silent switches which could be held in one hand were connected to two inputs of the programming equipment.

The picture cards used in the picture-naming task were constructed by the experimenter. Colored pictures were taken from magazines and glued on stiff 7 inch x 5 inch cardboard backings. Each experimental condition was associated with a discriminative stimulus. In one condition a row of six red lights was lit while in the other experimental condition no lights were lit. Primary reinforcement was delivered according to the schedule of reinforcement in effect in each experimental condition. The primary reinforcers used were small sugar coated chocolate candies (Smarties) and either orange or apple juice. The first candy received each session and subsequently every fifth candy was accompanied by a small sip of juice.

Preliminary Procedures

Prior to conducting the research it was necessary to establish a number of behaviors not already in the subjects repertoires. These behaviors and the training procedures used are described below.

It should be mentioned that Bobby had previously learned to make eye-contact and to name pictures. Thus the procedures appropriate to these behaviors were followed with Bobby not to establish the behaviors, but to ensure that they existed in high strength and to bring them under the stimulus control of the present experimental situation.

Shaping of Eye-Contact

Frequently in research of this type, attending has been defined as eye-contact (Kircher, Pear, and Martin, 1971; Martin, Moir, and Skinner, 1969) and the time spent attending has been an important dependent variable. Although eye-contact was not directly related to any dependent variable in this study, it was felt that previous shaping of eye-contact would facilitate subsequent procedures.

Eye-contact was shaped in the following manner:

The subject was seated behind the table in the experimental room. Initially the requirement for reinforcement was 1 second of eye-contact. In other words a reinforcer was delivered each time the child stared continuously at the experimenter's eyes for 1 second. The length of eye-contact time necessary for reinforcement was gradually increased throughout sessions until both subjects consistently made eye-contacts of five seconds' duration with the experimenter. This required two sessions with Sidney and four sessions with Bobby.

Shaping of Lever-Pressing

In this research an attending response was defined as each depression of a lever great enough to close a micro-switch. The experimenter held up a picture card with the blank side of the card facing the subject. In order to have the side of the card with the picture turned towards him, the subject was required to emit one lever press. Inattentive behavior was recorded as the amount of time in which the blank side of the card was held towards the subject, before a lever press occurred. Reinforcement was contingent on naming or imitating the name of the picture presented.

In order to ensure that the subject would be reinforced during the shaping of lever-pressing it was essential that the pictures to be presented were pictures whose names the subject could at least imitate. A few such pictures were obtained as follows, prior to the shaping of lever-pressing. The experimenter selected a few pictures at random and presented each to the subject with a verbal prompt. A prompt consisted of the experimenter asking the name of the picture and then saying the name; i. e. "What's that? A _____ (name of picture)." If the subject imitated the picture name correctly, the experimenter said "Good boy" and delivered a reinforcer. If the child did not correctly imitate the picture name the experimenter said "No" and ignored the child for five seconds. This was continued until two pictures had been found whose names the subject could imitate.

These two pictures were used during the reinforcement of lever-pressing. The experimenter held up a picture close to the lever with the blank side of the picture towards the subject. He then told the subject to press the lever. When the subject did so, the experimenter turned the card around so that the picture was towards the subject and said "What's that? A _____ (name of object)." If the subject imitated the name correctly he was reinforced. If he did not imitate the picture name correctly, the experimenter said "No", ignored the child for 5 seconds, then repeated the process. The verbal prompts for lever pressing were rapidly eliminated. Also the pictures were moved away from the lever until the experimenter was holding the pictures directly in front of himself. The two pictures were presented repeatedly in a random fashion. It should be mentioned that during these preliminary procedures and during the experiment proper, the experimenter did not attend to the subject while the subject was engaging in inattentive behaviors. The experimenter gazed directly down at the table until the child pressed the lever. Then the experimenter turned the card around, looked at the child and delivered the appropriate prompt or question. The procedure for shaping lever pressing was continued until both subjects would consistently press the lever in order to have the picture presented. This required 3 sessions with Bobby and 19 sessions with Sidney.

Picture-Naming Behavior

Although the subjects would imitate the names of pictures it was necessary to establish picture-naming behavior as well, prior to carrying out the experiment. This was accomplished in the following manner. The same two pictures that had been used in shaping lever pressing were now presented to the subject according to these steps:

(a) Contingent on a lever press, the first picture was presented and the experimenter said "What's that? A _____ (name of picture)."

(b) If the subject imitated the name, he was reinforced. If he did not imitate the name correctly within 5 seconds the experimenter said "No" and returned to (a).

(c) The experimenter next presented the same picture and said "What's that?". If the subject named it correctly he was reinforced. If the subject did not name it correctly within 5 seconds the experimenter said "No" and returned to (a).

(d) Steps (a) to (c) were repeated with the second picture.

(e) Steps (a) to (d) were repeated until the subject named the pictures at least 50 per cent of the time.

As well as establishing picture-naming behavior, the schedule of reinforcement was gradually increased during the above procedure from a continuous schedule of reinforcement (i. e. every correct response was followed by primary reinforcement) to a fixed-ratio schedule of reinforcement in which 5 correct responses were required for primary reinforcement. The experimenter said "Good boy" after each correct response but the candy dispenser eventually operated only after each fifth correct response. This procedure required 20 sessions with Sidney and 7 sessions with Bobby.

Misbehavior

Typically in research of this type a number of behaviors have been classified as misbehavior either because they compete with attending responses or because they are extremely disruptive. Punishment is then usually made contingent on these behaviors (e. g. Kircher, Pear, and Martin, 1971). This experimenter felt however, that it would not be appropriate to study the effects of schedules of reinforcement against a background of punishment. The administration of punishment on parts of the class of behavior called inattentiveness might confound the effects of the schedules of reinforcement on this class of behavior. Thus during the preliminary procedures and the experiment itself, the following rules were strictly adhered to.

(1) No punishment was made contingent on inattentive behaviors or disruptive behaviors. The subjects could turn in their seats,

bang on the table or equipment, play with the curtains behind them etc. In general they could do almost anything as long as they remained seated in the chair.

(2) The physical environment was arranged such that there was little opportunity for the subject to grab destructible items or apparatus crucial to the conduct of the experiment; thereby forcing the experimenter to attend to him. The stopwatch and microphone were kept on the counter to the experimenter's right, out of the reach of the subject. The only objects on the table were the picture being worked on and the sheet for recording data. The subject was seated with the back of his chair against the wall and the table was pushed within an inch or two of his chest. This restricted the reach of the subject to the length of his arm. As a result the only objects within the subject's reach were the objects on the table. The experimenter held the data sheet on the table by resting one arm on it. The picture being used was held in the other hand. If the subject grabbed for these the experimenter simply kept a firm grip and did not attend to the subject. Any attempts to grab the objects not on the table soon extinguished, simply because the subject was never successful in reaching them. Grabbing for the two items on the table also decreased in frequency during the conduct of the experiment.

(3) The only behaviors punished were those which would remove the subject from the contingencies of reinforcement in effect during the sessions. The only two behaviors which fitted this criterion were sleeping and leaving the chair. If the subject stood up or closed his eyes for more than a few seconds the experimenter said "No" and slapped the child's hand sharply. Both these behaviors were very infrequent.

(4) Because the presentation of pictures always occurred just prior to reinforcement it is possible that the presentation of pictures acquired the status of a conditioned reinforcer. If so it could be argued that pictures should be presented only while the subject was sitting quietly so as not to superstitiously reinforce "misbehaviors" which might be occurring along with lever pressing. Without denying the possible validity of this argument the experimenter nevertheless presented pictures contingent on lever pressing regardless of the other behavior of the subject. It was felt that differential presentation of pictures could confound the effects of the schedules of reinforcement; e. g. one reinforcement schedule might produce more "emotional" behaviors than another, and if the experimenter did not present pictures to the subject while he was engaging in these behaviors, the dependent variables could be affected. These effects would not be a result of the independent variables, but rather a result of the differential presentation of pictures.

(5) While waiting for the subject to press the lever, the experimenter did not attend to him. The experimenter looked down at the table. This was to ensure that the experimenter's attention would not act as a reinforcer to maintain "undesirable" behavior on the part of the subject.

Word Baseline

Since the experiment was to involve a comparison of the effects of two different schedules of reinforcement on picture-naming behavior, it was necessary to determine beforehand, the words that each subject could pronounce and the pictures they could or could not identify. If this was not done, any differences in picture-naming behavior rather than being a result of the schedule of reinforcement in effect, in either condition, might be a result of the pictures in one condition being known prior to the experiment or the picture-names in one condition not being pronounceable. In order to ensure that all pictures to be taught were unknown and pronounceable the following steps were taken:

- (1) The experimenter presented a picture and said "What's that?"
- (2) If the child correctly named the picture the experimenter said "Good boy" and proceeded to the next picture. If the child did not correctly name the picture the experimenter said "What's that" A _____ (name of picture)." If the child correctly imitated the picture name the experimenter said "Good boy" and proceeded to the next picture.

If the picture name was not correctly imitated, that picture was discarded from the experiment.

(3) A large set of pictures was presented as above three times on three consecutive days. Pictures that were correctly named without prompts all three times were called known pictures.

Pictures that were not correctly named but whose names were correctly imitated all three times were called unknown pictures.

All other pictures were eliminated from the experiment. (See Table 1). During these procedures every fifth "Good boy" was accompanied by the operation of the candy dispenser and the delivery of a candy.

Pictures categorized as known and unknown were then randomly divided into two pools. One pool of unknown words was taught according to one schedule of reinforcement and the other pool according to the other schedule of reinforcement. The pools of unknown and known words are shown in Tables 2 and 3. A second word baseline was taken after session 20 with Bobby to obtain additional unknown words. The same procedures as above were followed for selecting known and unknown words and for dividing them into pools. The pools of unknown and known words resulting from this baseline procedure are also shown in Table 3.

Table I
Sample Baseline Table

Subject _____					Dates _____
Symbols:	correctly imitated	-2			
	correctly named	-1			
	incorrectly imitated	-x			
Picture		Trial			Final Picture
Name	1	<u>2</u>	<u>3</u>		Category
ball	1	1	1		known
car	2	2	2		unknown
house	1	2	2		discarded
doll	2	x	2		discarded
tree	x	x	x		discarded
baby	1	1	2		discarded
tent	1	1	x		discarded

Table 2

Experimental Word Pools for Sidney

Condition I		Condition II	
<u>Unknown</u>	<u>Known</u>	<u>Unknown</u>	<u>Known</u>
bed *	bird	cat *	ball
boy **	chair	bus **	car
soup *		shirt *	pants
comb *		cake *	
boat *		baby *	
cookie *		pot *	
bike **		puppy **	
drum **		dress **	
corn		house *	
nurse **		boat *	
pipe		bear **	
stairs		tie *	
knife		sock	
wagon		pie *	
candy		egg **	
hat		blanket	
brush		airplane	
peas		gun	
bottle		T-V	
pants		bread	
toast		train	
sweater		soap	
tree		watch	
tire		book	

* Words learned

** Words eliminated after not being learned within the time limits described in the picture-naming procedure.

Table 3

Experimental Word Pools for Bobby

Condition I		<u>Known</u>	Condition II		<u>Known</u>
<u>Unknown</u>			<u>Unknown</u>		
Baseline 1	Baseline 2		Baseline 1	Baseline 2	
meat *	sheet *	ball	boot *	rug *	apple
bear *	drill	bed	stairs *	thread *	soup
tie *	bow	cat	brush *	mask *	sock
bride *	rain *	mitt	shorts *	bus*	car
dish *	glove	house	pants *	tent *	nurse
ship *	doll	boat	lion *	saw*	clock
train *	saddle	bird	fish *	nail	baby
peas *	battery	pencil	candle *	grapes	book
bottle *	children	boy	bread *	perfume	tree
deer *	sink	puppy	sofa *	cow	cake
teapot *	sweater	cookie	basket *	brush	candy
snake *	mattress	juice	drum *	nailpolish	horse
razor *			corn *	cheese	gum
stove *			hot dog *	toaster	
carrots			knife *	rocket	
ice cream *			pancakes *		
pillow *			purse *		
			cradle *		
mixer			jello *		
sword *					

* Words learned.

Experimental Procedures

The purpose of this research was to compare the effects of two different schedules of reinforcement on the picture-naming behavior of retarded children. Sessions were conducted in the morning, five days a week except during illnesses. In Condition I, a 20 minute session was run under a Fixed-Ratio schedule of reinforcement; then following a 10 minute break, a second 20 minute session was run under an Interlocking schedule of reinforcement in Condition II. The sequence of the conditions was alternated each subsequent session.

Phase I.

A fixed-ratio schedule in which five responses were required for reinforcement (FR 5) was in effect in Condition I. A candy was delivered after every fifth correct response, in combination with the experimenter's response "Good boy". The first candy of each session was accompanied by juice and subsequently every fifth candy was accompanied by a drink of juice. The reinforcement interval lasted 15 seconds, after which time the experimenter held up the next picture card with its back facing the subject. The picture card was not held up until 15 seconds after the delivery of the reinforcer even if the reinforcer was consumed before the end of the 15 second interval.

No scheduled consequences occurred if the subject pressed the lever during the 15 second interval. At the end of the interval the picture card was held up even if the reinforcer had not yet been consumed. After each incorrect response the experimenter said "No" and ignored the subject for 5 seconds. This procedure of ignoring the subject was stopped in both conditions after session 10 with Bobby and session 15 with Sidney as a result of other research which indicated that it was not an effective procedure for eliminating errors (Martin, Hardy, and McDonald, 1970). The experimenter then said "No" after incorrect responses and immediately proceeded with the task. Incorrect responses included improperly pronounced responses, instances on which no response occurred within 5 seconds, and responses which did not correctly name the picture. The experimenter held two small pushbutton switches in one hand. He closed one switch each time the subject emitted a correct response. Each fifth button press automatically operated the candy dispenser. The second switch was used to start the timer which recorded time spent in inattentive behavior.

In Condition II the red stimulus lights were lit. Correct responses and errors were treated the same as in Condition I except that correct responses were reinforced according to an interlocking schedule of reinforcement. The interlocking schedule of reinforcement

was programmed such that the number of responses required for reinforcement increased with the passage of time since the previous reinforcement. Specifically, reinforcement would occur after the fifth correct response, provided that the fifth response occurred within a certain time (t) since the previous reinforcement. If the fifth correct response did not occur within this time limit the response requirement automatically increased by two responses; i. e. to seven. If this new requirement was not met within an additional time period t , the response requirement increased by two additional responses. The response requirement continued to increase by two responses each time period t , to a maximum of 15 responses. In general then, the interlocking schedule of reinforcement was an FR 5 schedule of reinforcement which increased by 2 responses after each time period t since the previous reinforcement, to a maximum of 15 responses (FR 15). Each reinforcement reset the schedule to its initial value. In order to ensure that the subject encountered the contingencies specified by the interlocking schedule it was necessary to avoid extreme values of t . If t was extremely long the subjects would in effect be under the control of an FR 5 schedule of reinforcement. Similarly if t was extremely short the subjects would in effect be under the control of an FR 15 schedule of reinforcement. To avoid either of these possibilities, t was initially set at

a high value (2 minutes) and was gradually reduced until the subject was being reinforced on the average for every 8 to 10 correct responses. This general requirement was met after session 19 with Sidney and session 6 with Bobby. For both subjects the final time period of the interlocking schedule was $t = 60$ sec. This interlocking schedule is presented diagrammatically (Reynolds, 1968) in Figure 1, and compared to a fixed-ratio schedule of reinforcement.

The interlocking schedule was programmed automatically as was the fixed-ratio schedule. Each time a correct response occurred the experimenter simultaneously said "Good boy" and pressed a push-button. The programming equipment activated the candy dispenser when the requirement was met. Phase I lasted 24 sessions for Sidney and 21 sessions for Bobby.

Picture-Naming Procedure.

The procedure used for teaching the children to name pictures was similar to that described by Martin (1969). Refer to Table 4 when following the description of this procedure.

(1) The experimenter presented a randomly chosen unknown picture and said "What's that? A _____ (name of object)." This was called a prompt trial. If the subject correctly imitated the name, the experimenter said "Good boy", put the card down, and proceeded to step (2). If the subject did not correctly imitate the name within 5 seconds, the experimenter said "No", put the card down, and then

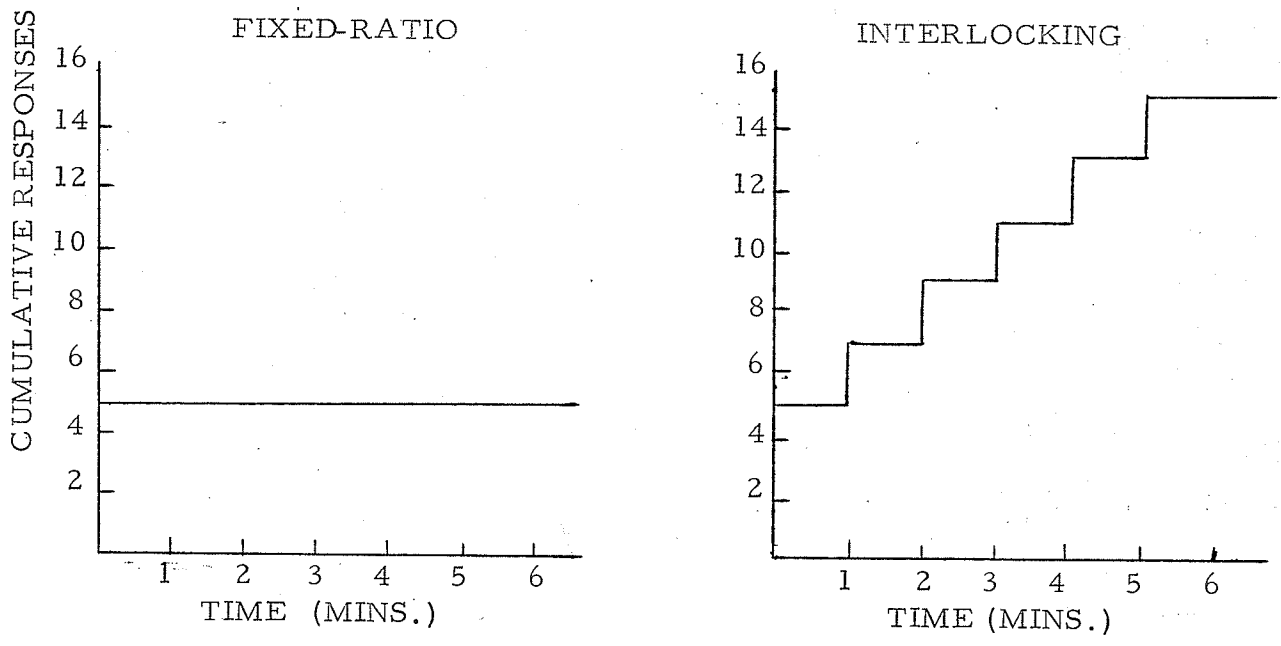


Fig. 1 A diagrammatic representation of a Fixed-Ratio schedule of reinforcement (left panel) and an Interlocking schedule of reinforcement (right panel). Every fifth response is reinforced under the fixed-ratio schedule of reinforcement. Every fifth response is reinforced under the interlocking schedule of reinforcement only if the fifth response occurs within one minute of the previous reinforcement. If the fifth response does not occur within one minute, the requirement increases by two responses. The requirement continues to increase by two responses each subsequent minute to a maximum of fifteen. The origin of each diagram indicates the point of occurrence of the previous reinforcement. The solid line in each figure represents the cumulative number of responses required for reinforcement at various time intervals since the previous reinforcement.

Table 4

Daily Session Sheet for the Picture-Naming Procedure

S Sidney

E Carl

Date January 10

Time 9:00

NW puppy

NW dress

STEP ↓	1	NW P		NW P		NW P	
	2	NW Q		NW Q		NW Q	
3		KW ₁ P		KW ₂ P		KW ₃ P	
		KW ₁ Q		KW ₂ Q		KW ₃ Q	
4		NW Q		KW ₂ Q		KW ₃ Q	
		NW Q		NW Q		NW Q	
		KW ₁ Q		KW ₂ Q		NW Q	
		KW Q		NW Q		KW ₃ Q	

NW P		NW P		NW P
NW Q		NW Q		NW Q
KW ₁ P		KW ₂ P		KW ₃ P
KW ₁ Q		KW ₂ Q		KW ₃ Q
KW ₁ Q		NW Q		NW Q
KW ₁ Q		KW ₂ Q		KW ₃ Q
NW Q		KW ₂ Q		NW Q
NW Q		NW Q		KW ₃ Q

Symbols

NW - unknown (new) word, prompt trial
P

NW - unknown (new) word, question trial
Q

KW - known word, prompt trial
P

KW - known word, question trial
Q

Steps 1-5 are discussed fully in the text under the heading, Picture-Naming Procedure.

re-presented it with another prompt. He continued to do this until the subject correctly imitated the name.

(2) The experimenter presented the same unknown picture and said "What's that?". This was called a question trial. If the subject correctly named the picture the experimenter said "Good boy" and proceeded to step (3). If the subject made an error the experimenter said "No" and returned to step (1).

(3) When step (2) was successfully completed the procedures in steps (1) and (2) were carried out on a randomly selected known picture.

(4) Four more question trials were given, two question trials for the known word and two for the unknown word. The order of these four question trials changed in each column of the session sheets to prevent the subjects from learning the order of presentation of pictures. See Table 5 for a schematic representation of steps 1-4.

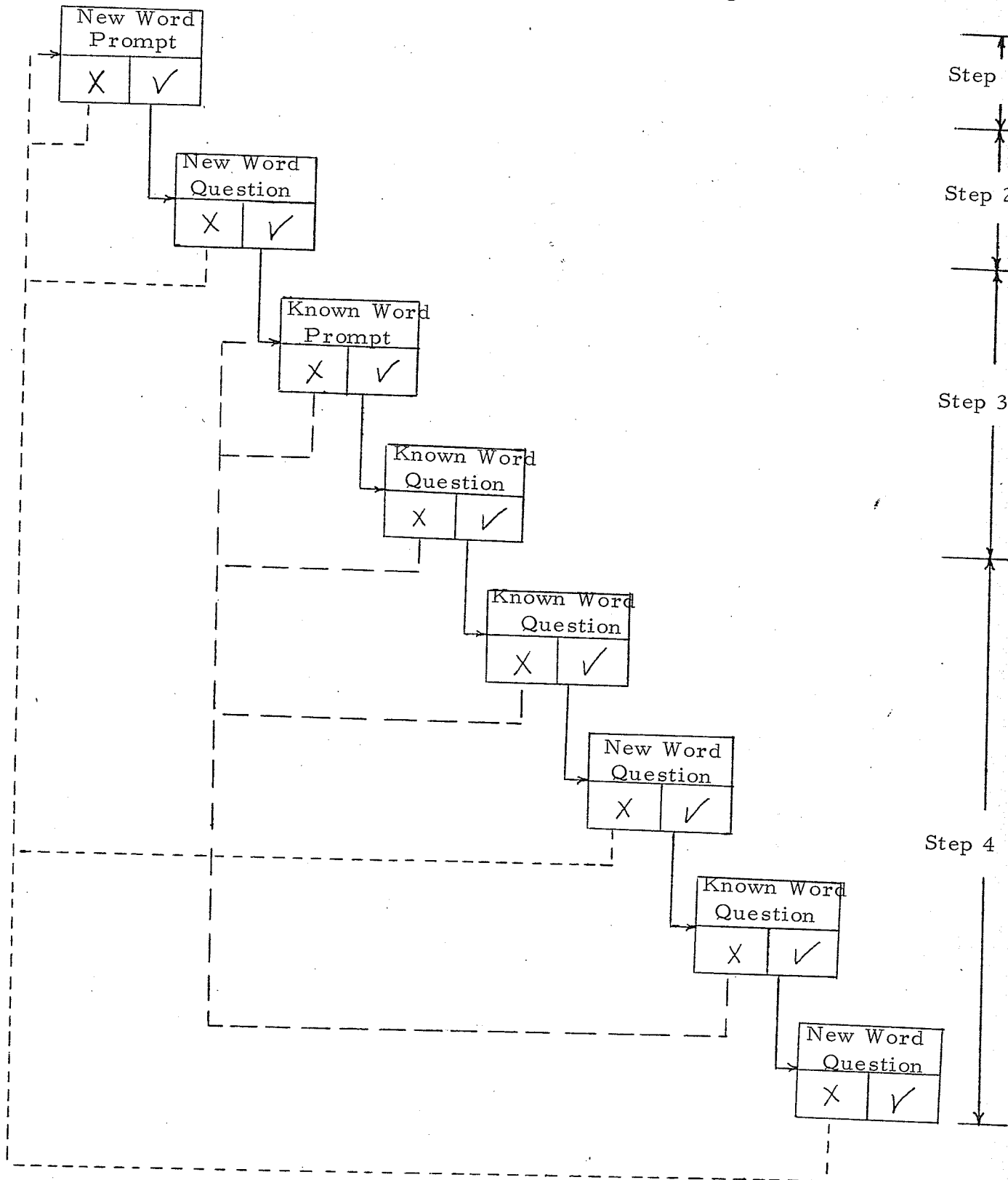
(5) Steps 1-4 were repeated with same unknown picture and a second known picture, and then again with the same unknown picture and a third known picture.

(6) Steps 1-5 were carried out for each unknown picture.

When Steps 1-5 had been successfully completed for an unknown word, that word was said to have "reached criterion". It was then tested at the beginning of the next 3 consecutive sessions. If the subject correctly identified the picture on these three occasions, it acquired the status of a learned word. If it was incorrectly recalled

Table 5

Schematic Representation of Steps 1-4 of Picture-Naming Procedure



on any of these sessions it was returned to step (1) and the procedure was repeated. Unknown words were eliminated from the experiment and a new unknown word presented if either of the following requirements were met.

(1) If at the end of the sixth session with a particular unknown word, it had not reached criterion, it was discarded.

(2) If an unknown word was not learned after the sixth time it reached criterion, it was discarded.

According to these requirements, five words were eliminated from the word pool in the Interlocking condition and four words from the Fixed-Ratio condition with Sidney. No words were eliminated from the word pools of either condition with Bobby.

Phase II

Any difference in the effects of the fixed-ratio schedule of reinforcement and the interlocking schedule of reinforcement in Phase I might simply have occurred because of the average more correct responses were emitted per reinforcement under the interlocking schedule than under the fixed-ratio schedule. Thus any differences in the effects of the two schedules might be eliminated simply by increasing the requirement of the fixed-ratio schedule to equal the mean number of correct responses reinforced on the interlocking schedule. The average

number of responses per reinforcement over all sessions in the interlocking condition was calculated. The value obtained was 8 responses per reinforcement for both subjects. Figure 2 shows the mean number of responses per reinforcement for all sessions. (It should be noted that the mean number of responses per reinforcement in the Fixed-Ratio condition doesn't always equal the schedule requirement). This is because sessions did not always end immediately after a reinforced response. Sessions ended after exactly 20 minutes without regard to the number of correct responses that had been made. The requirement for reinforcement under the fixed-ratio schedule was then increased from 5 responses to 8 responses. The interlocking schedule of reinforcement remained at the same value as in Phase I. Phase II lasted 7 sessions for Bobby and 9 sessions for Sidney.

Phase III

Phase III was carried out to determine if any differences in the results of Phases I and II were a result of the experimental manipulation in Phase II. If any differences in the results of Phases I and II were a result of increasing the requirement of the fixed-ratio schedule, then the differences should disappear if the value of the fixed-ratio schedule was changed back to the Phase I value of that schedule.

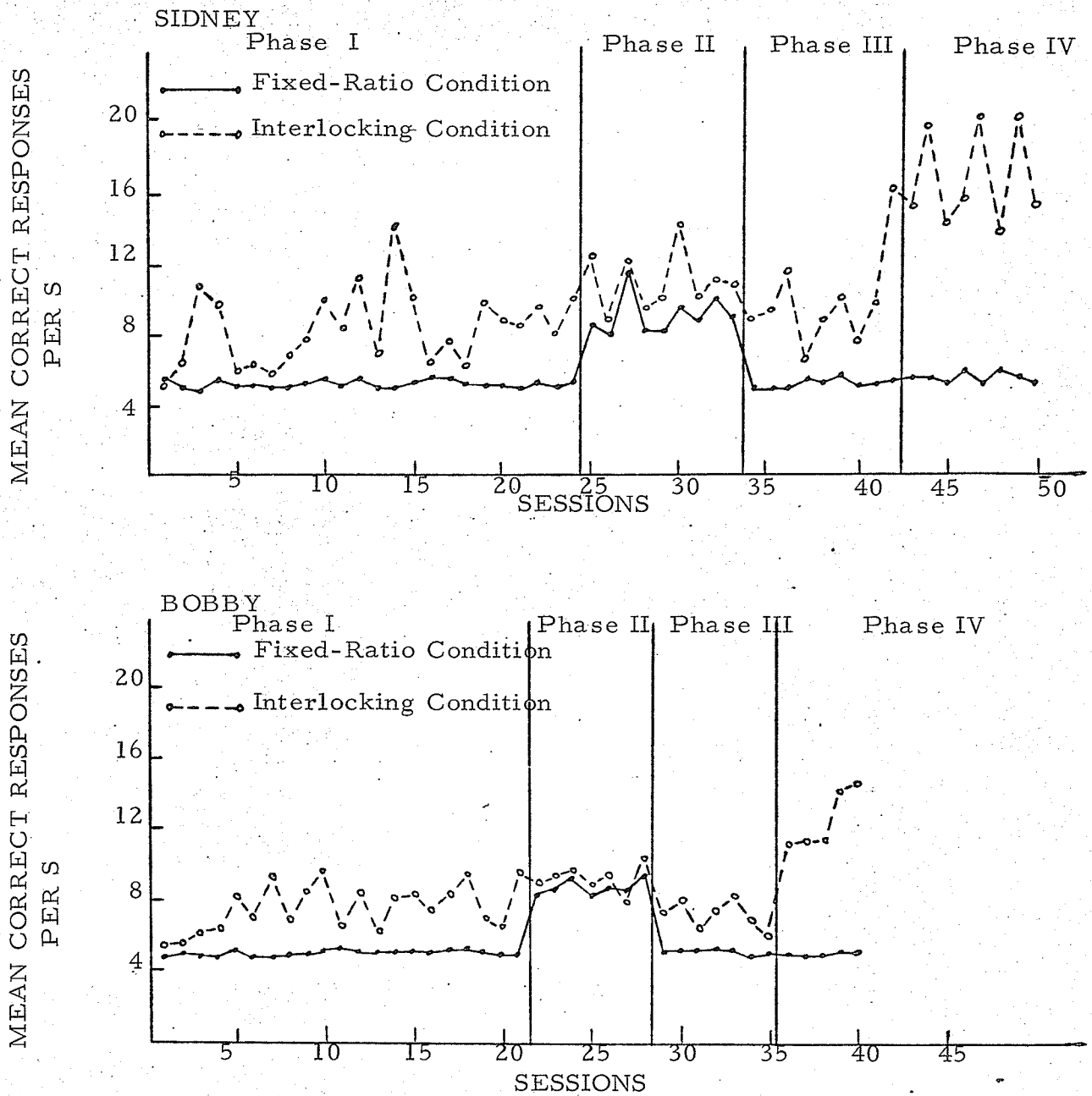


Fig. 2 The mean number of correct responses per reinforcement (S) over all sessions for Sidney and Bobby. The value of the schedules of reinforcement in each phase are shown in the chart below

SIDNEY				BOBBY			
Phases	Sessions	Schedule	Values	Phases	Sessions	Schedule	Values
		FR	Interloc.			FR	Interloc.
I	1-2	5	t=120	I	1-2	5	t=120
	3-5	5	t=80		3-5	5	t=70
	6-19	5	t=70		6-21	5	t=60
	20-24	5	t=60	II	22-28	8	t=60
II	25-33	8	t=60	III	29-35	5	t=60
III	34-42	5	t=60	IV	36-40	5	t=30
IV	43-50	5	t=30				

The requirement for reinforcement under the fixed-ratio schedule was reversed from eight responses to the original 5 responses. The interlocking schedule of reinforcement remained the same as previously. Phase III lasted 7 sessions for Bobby and 9 sessions for Sidney.

Phase IV

Phase IV was carried out to determine if any differences in the effects of the fixed-ratio and interlocking schedules of reinforcement in the previous three phases could be accentuated by decreasing the time requirement of the interlocking schedule. The time requirement of the interlocking schedule of reinforcement was changed from $t=60$ sec. to $t=30$ sec. Every fifth response was reinforced provided the fifth response occurred within 30 seconds of the previous reinforcement. If the fifth response had not occurred after 30 seconds, the requirement increased by 2 responses. It continued to increase by two responses each subsequent 30 seconds up to a maximum of 15 responses. The fixed-ratio schedule of reinforcement remained the same as in Phase III. This phase lasted 5 sessions for Bobby and 8 sessions for Sidney.

Dependent Variables

The following dependent variables were used in this research:

(1) The number of correct responses. This measure included those instances on which pictures were correctly named and those instances on which picture names were correctly imitated. Correct responses were recorded on the data sheet (Table 4) by the experimenter. Also, as mentioned previously, the experimenter operated a hand switch simultaneously with saying "Good boy" after each correct response. Each operation of the hand switch operated on electromechanical counter so that correct responses were also recorded by the programming equipment.

(2) The number of errors. This measure included all instances in which a correct response did not occur within five seconds of the prompt or question. Errors were recorded only on the data sheet by the experimenter.

(3) A ratio of incorrect responses to total response opportunities per session. Total response opportunities included all instances of correct and incorrect (including no response) responses.

(4) The cumulative number of words learned. A learned word was a picture name which had been correctly identified within steps 1-5 of the picture-naming procedure and which had been correctly identified on three successive sessions.

(5) Time spent engaging in inattentive behavior. This variable was recorded cumulatively for each session. This was the time

between the presentation of a blank side of a card and the lever press of the subject. Simultaneously with holding up the blank side of a card, the experimenter operated a handswitch. A digital counter operated once every second from the time the handswitch was operated until the subject pressed the lever. This interval of time was time spent engaging in inattentive behavior. It should be mentioned that each operation of the digital counter during the time spent in inattentive behavior could be heard by the subject. The operation of the counter after each correct response was likely not heard because the experimenter said "Good boy" simultaneously with the operation of the counter.

Inter-Observer Reliability

The picture-naming task required that the experimenter decide whether the subjects' responses were correct or incorrect. The consistency of these decisions was checked by computing an inter-observer reliability coefficient. Sixteen experimental sessions were recorded on tape. An independent observer listened to 453 verbal responses from these tapes. Since the purpose of the observer was to check the consistency of the experimenter's decisions, he was allowed to hear the subject pronounce each word to be scored, two or three times, and to hear the experimenter's decision. Once acquainted with the experimenter's criteria for correct and incorrect

responses, he listened to the tapes. The tape was stopped after each response and the observer was required to score the response as correct or incorrect prior to hearing the experimenter's decision. A disagreement was recorded between the observer's decision and the experimenter's decision if either of the following events occurred.

(1) If in the opinion of the observer the subject did not respond at all (this was included in the calculation because the majority of the subjects' errors were of this type), or did not respond correctly within 5 seconds and the experimenter did not say "No", a disagreement was recorded. (If the experimenter did say "No" an agreement was recorded.)

(2) If in the opinion of the observer the subject did respond correctly within five seconds and the experimenter said "No", a disagreement was recorded. (If the experimenter said "Good boy" an agreement was recorded).

Two inter-observer reliability percentages were calculated.

(a) The number of agreements on responses that the experimenter called correct divided by the number of agreements plus disagreements on responses that the experimenter called correct.

(b) The number of agreements on responses that the experimenter called incorrect divided by the number of agreements plus disagreements on the responses that the experimenter called incorrect.

The resulting inter-observer reliability coefficients were as follows: For Sidney the reliability coefficient for correct responses was 94% and for incorrect responses was 79%. For Bobby the reliability coefficient for correct responses was 97% and for incorrect responses was 88%.

CHAPTER III

RESULTS

Inattentive Time

Figure 3 shows that for both subjects there was a general increase in inattentive time per session in both conditions during the first 10 to 15 sessions. From session 5 to the end of Phase I, Sidney spent less time engaging in inattentive behavior during the interlocking condition than during the fixed-ratio condition. This was also true for Bobby after session 14. During Phase II the amount of time Sidney and Bobby spent engaging in inattentive behavior increased in both the fixed-ratio and interlocking conditions as compared to Phase I. However both subjects continued to spend more time engaging in inattentive behavior in the fixed-ratio condition than in the interlocking condition. The amount of time both subjects spent engaging in inattentive behavior decreased in both conditions during Phase III as compared to Phase II. As before, both subjects spent more time engaging in inattentive behavior in the fixed-ratio condition. During Phase IV the amount of time Sidney spent in inattentive behavior increased in both conditions as compared to the previous phase. Bobby, on the other hand, spent less time engaging in inattentive behavior in both condition, than in the previous phase. The results of each subject also differed in that Bobby continued to spend less time engaging in inattentive behavior in the interlocking

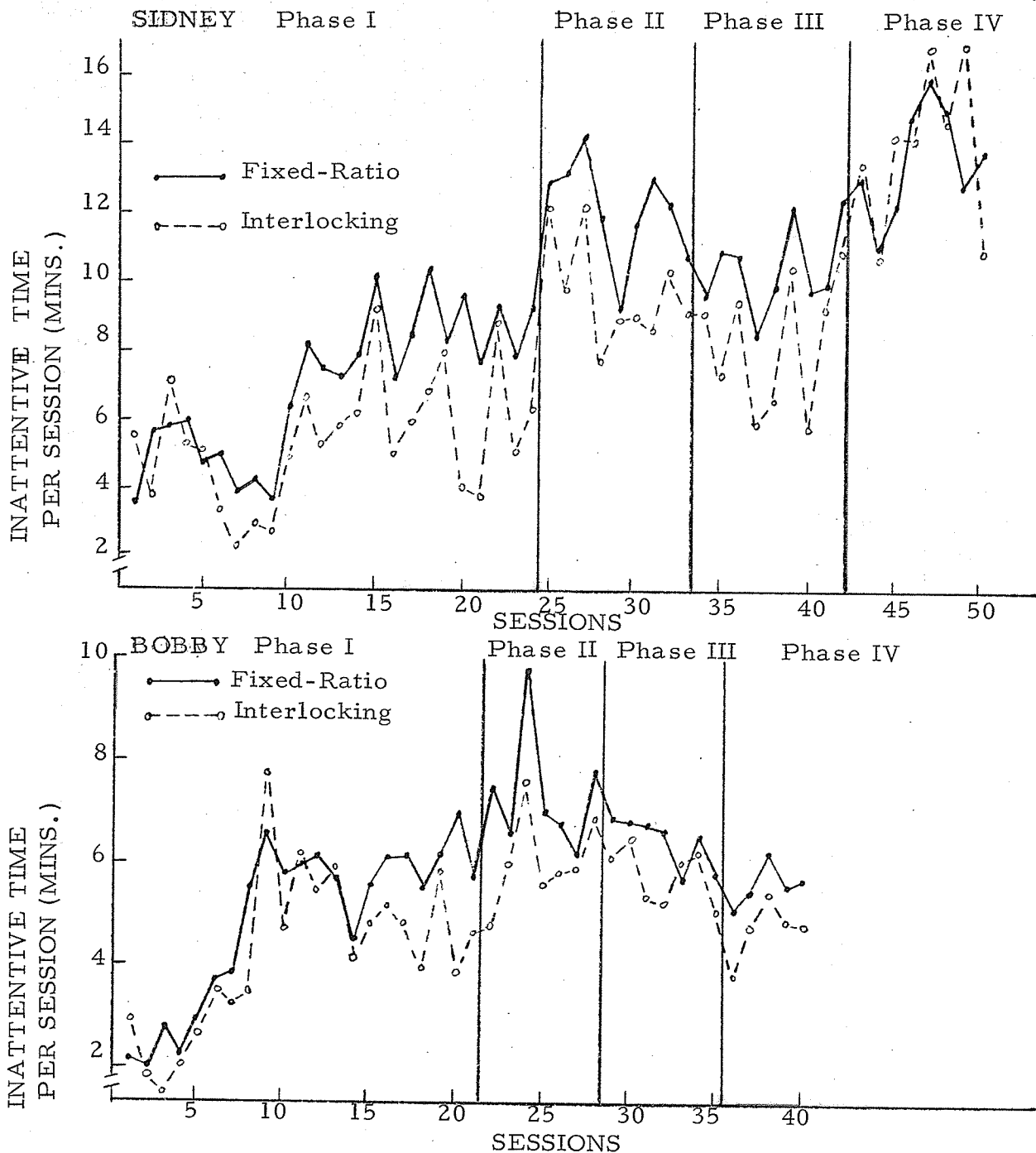


Fig. 3 The amount of inattentive time per session for Bobby and Sidney in condition I (Fixed-Ratio) and condition II (Interlocking) over all sessions. The values of the schedules of reinforcement in each phase are shown in the chart below.

SIDNEY				BOBBY			
Phases	Sessions	Schedule	Values	Phases	Sessions	Schedule	Values
		FR	Interloc.			FR	Interloc.
I	1-2	5	t=120	I	1-2	5	t=120
	3-5	5	t=80		3-5	5	t=70
	6-19	5	t=70		6-21	5	t=60
	20-24	5	t=60		II	22-28	8
II	25-33	8	t=60	III	29-35	5	t=60
III	34-42	5	t=60	IV	36-40	5	t=30
IV	43-50	5	t=30				

condition, while Sidney spent as much or more time engaging in inattentive behavior in the interlocking condition than in the fixed-ratio condition.

Figure 4 shows the mean amount of inattentive time over the last three-fifths ($3/5$) of the sessions in each phase. It should be mentioned that the mean of each variable was calculated only for the last three-fifths of the sessions in each phase in order to eliminate the early sessions during which the behavior was adjusting to the new condition. In all cases the number obtained was rounded to the nearest whole number (e. g. the last 14 sessions would be used to represent the last three-fifths of the sessions in a phase containing 24 sessions). Note in figure 4 that for both subjects, in both conditions, the mean amount of inattentive time over the last three fifths sessions of Phase III was lower than during Phase II but not as low as during Phase I.

Correct Responses

Figure 5 shows that both Sidney and Bobby very consistently emitted more correct responses in the interlocking condition than in the fixed-ratio condition during Phases I, II and III. This was also the case during Phase IV except that with Sidney the difference in the number of correct responses per session in each condition was

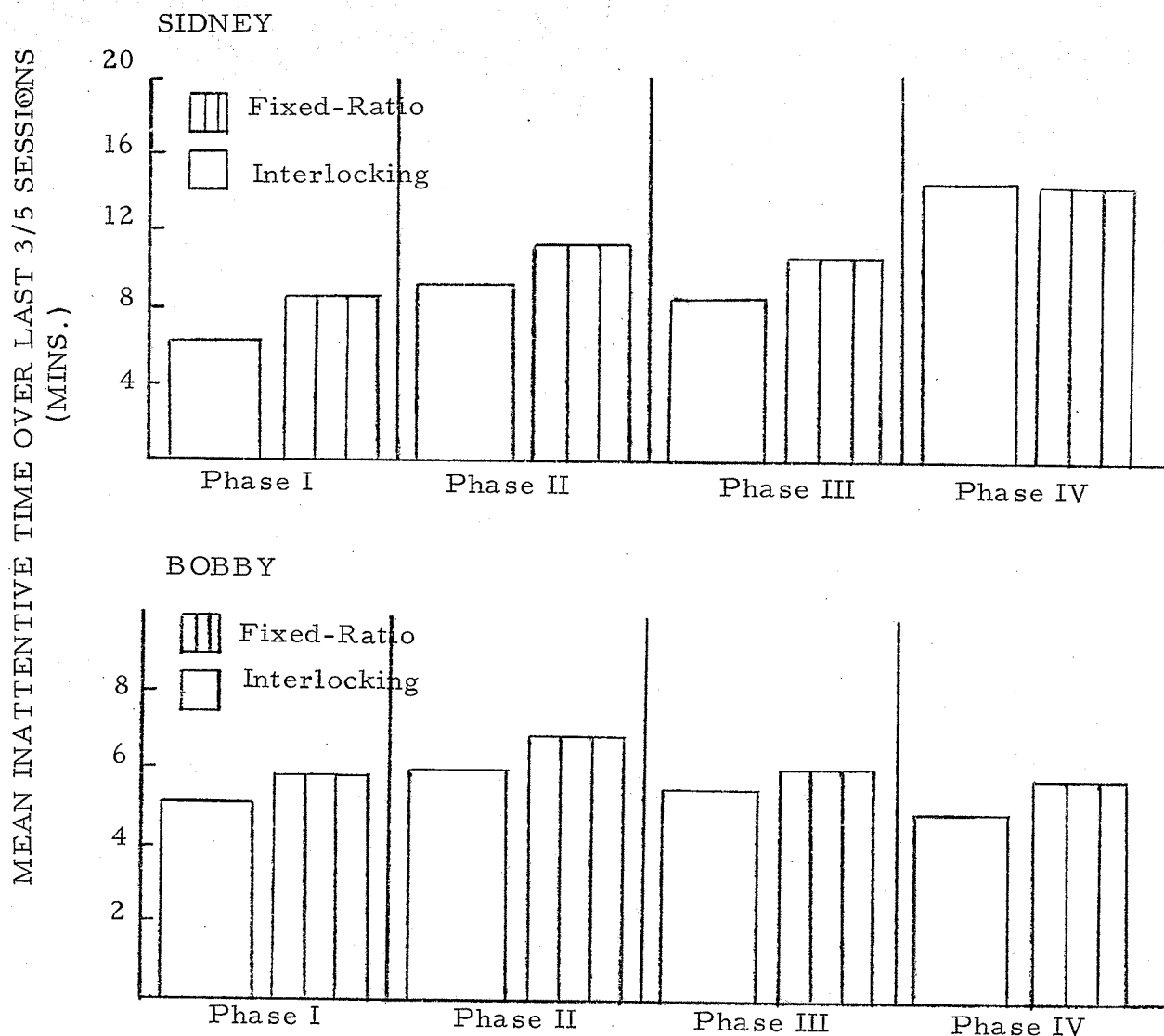


Fig. 4 The mean amount of inattentive time over the last 3/5 of the sessions of each phase for Sidney and Bobby. The values of the schedules of reinforcement during each phase are shown in the chart below.

SIDNEY				BOBBY			
Phases	Sessions	Schedule	Values	Phases	Sessions	Schedule	Values
		FR	Interloc.			FR	Interloc.
I	1-2	5	t=120	I	1-2	5	t=120
	3-5	5	t=80		3-5	5	t=70
	6-19	5	t=70		6-21	5	t=60
	20-24	5	t=60	II	22-28	8	t=60
II	25-33	8	t=60	III	29-35	5	t=60
III	34-42	5	t=60	IV	36-40	5	t=30
IV	43-50	5	t=30				

TOTAL NO. OF CORRECT RESPONSES

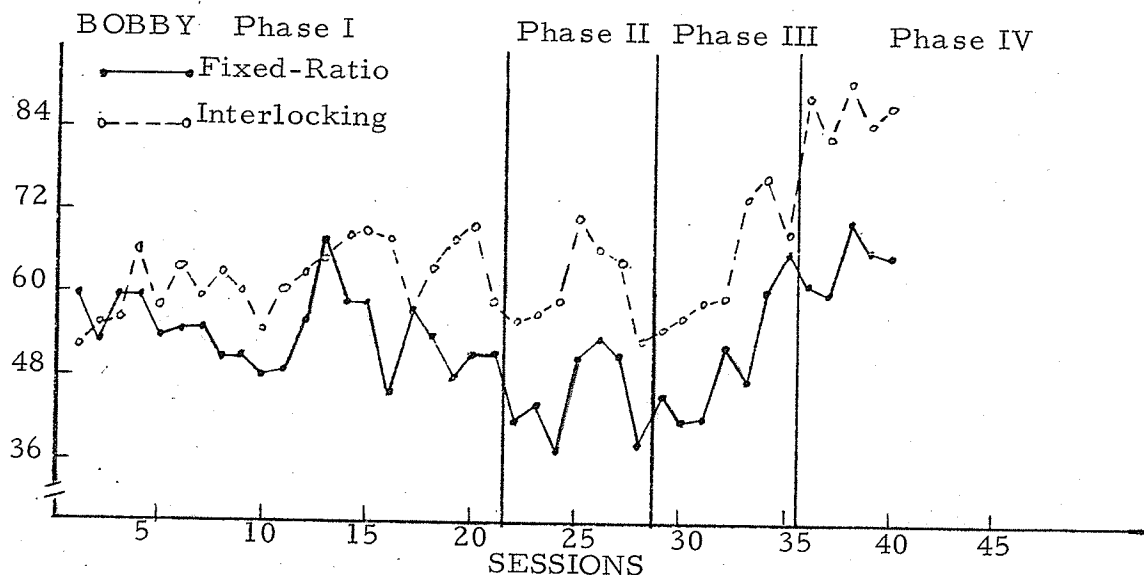
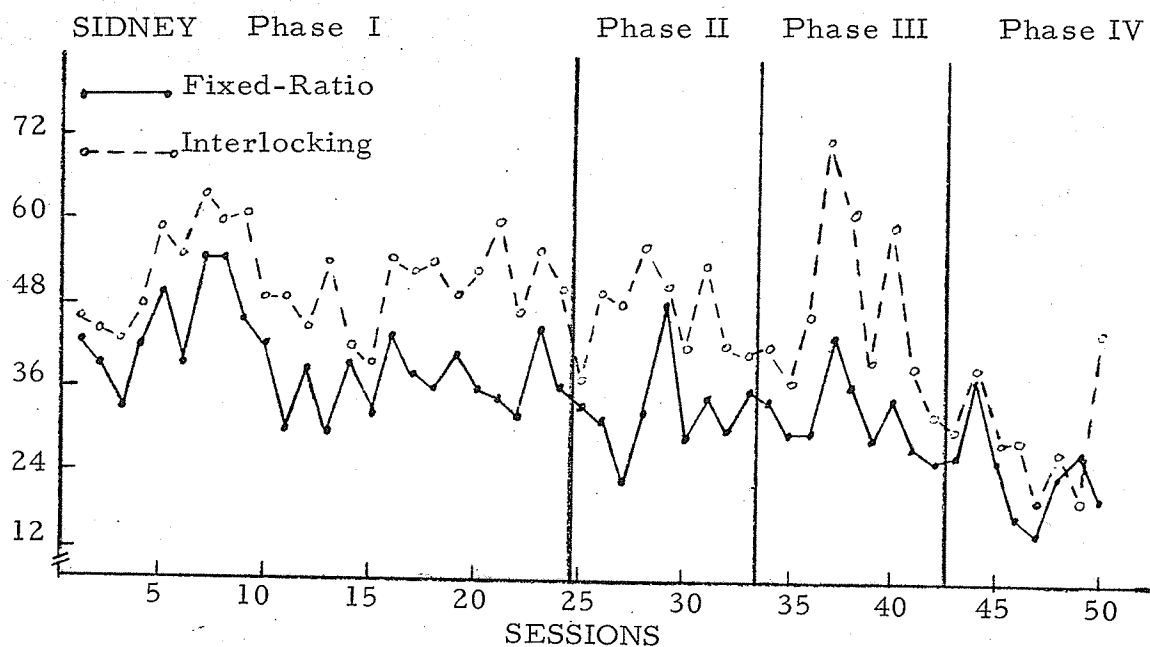


Fig. 5 The total number of correct responses over all sessions for Sidney and Bobby in the interlocking and fixed-ratio conditions. The values of the schedules of reinforcement in each condition are shown in the chart below.

SIDNEY				BOBBY			
Phase	Sessions	Schedule	Values	Phase	Sessions	Schedule	Values
		FR	Interloc.			FR	Interloc.
I	1-2	5	t=120	I	1-2	5	t=120
	3-5	5	t=80		3-5	5	t=70
	6-19	5	t=70		6-21	5	t=60
	20-24	5	t=60	II	22-28	8	t=60
II	25-33	8	t=60	III	29-35	5	t=60
III	34-42	5	t=60	IV	36-40	5	t=30
IV	43-50	5	t=30				

not nearly as large or consistent as in the previous three phases. In general Sidney emitted fewer correct responses in both conditions in Phase IV than in any previous phase. Bobby however, emitted more correct responses in both conditions in Phase IV than in any previous phase.

Note in figure 6 that there was a slight decrease in the mean number of correct responses emitted by both subjects in both conditions during Phase II as compared to Phase I. During Phase III there was little difference in the mean number of correct responses Sidney emitted over the last three-fifths of the sessions in both conditions, as compared to the mean number of correct responses he emitted over the last three-fifths of the sessions of Phase II. Bobby on the other hand emitted a slightly greater mean number of correct responses in both conditions over the last three-fifths of the sessions of Phase III as compared to Phase II.

Errors

Although the interlocking schedule had desirable effects with respect to decreasing the amount of inattentive time and increasing the number of correct responses, it did not consistently decrease the number of errors made by both subjects.

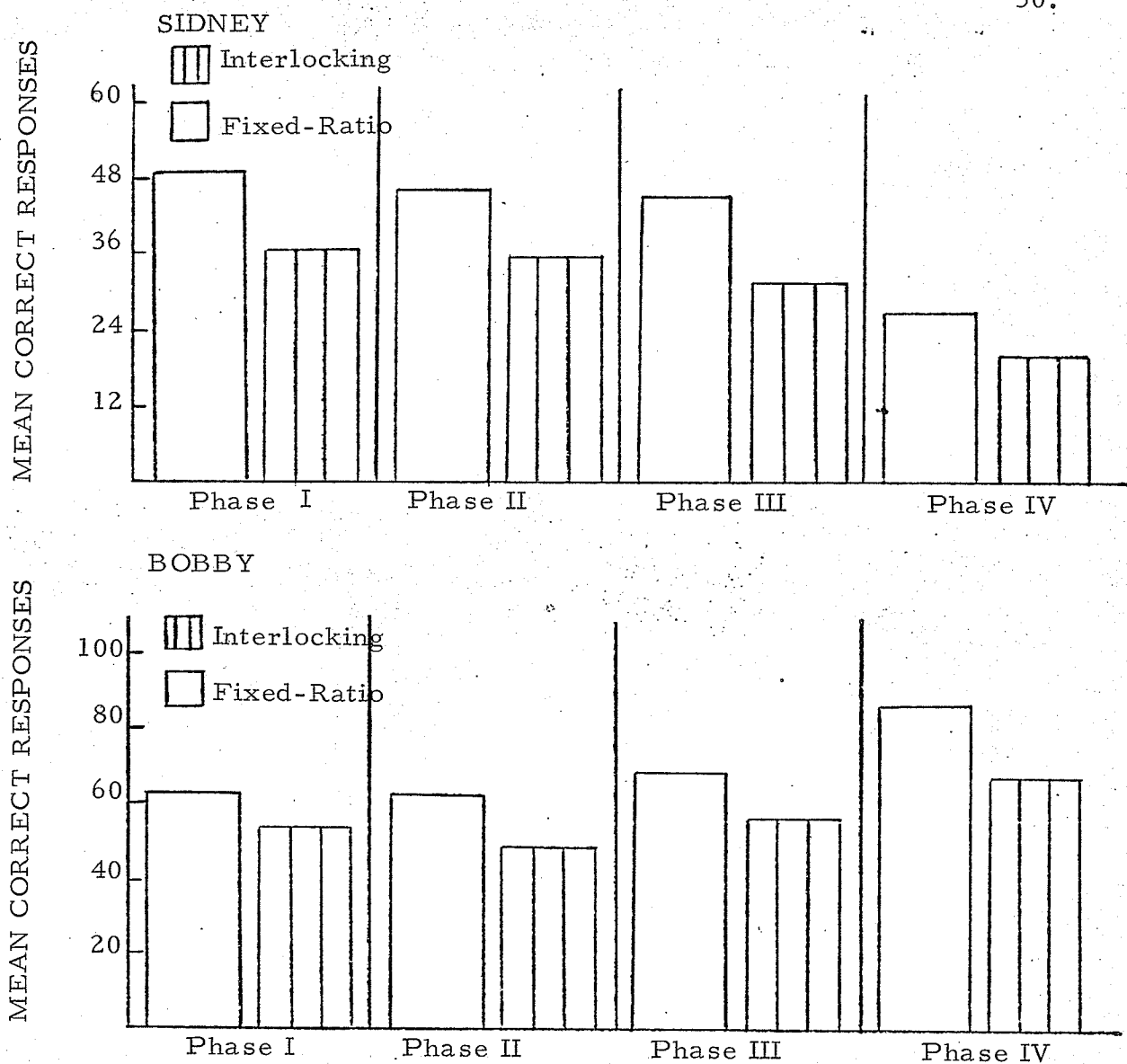


Fig. 6 The mean number of correct responses over the last 3/5 sessions of Phases I-IV. The values of the schedules of reinforcement in each phase are shown in the chart below.

SIDNEY				BOBBY			
Phase	Sessions	Schedule Values		Phase	Sessions	Schedule Values	
		FR	Interloc.			FR	Interloc.
I	1-2	5	t=120	I	1-2	5	t=120
	3-5	5	t=80		3-5	5	t=70
	6-19	5	t=70		6-21	5	t=60
	20-24	5	t=60	II	22-28	8	t=60
II	25-33	8	t=60	III	29-35	5	t=60
III	34-42	5	t=60	IV	36-40	5	t=30
IV	43-50	5	t=30				

Figure 7 shows that neither Sidney nor Bobby made consistently fewer errors in one condition than in another during Phase I. This was also the case for Sidney during Phase II. Bobby however, generally made fewer errors in the interlocking condition than in the fixed-ratio condition during Phase II. During Phases III and IV, Sidney generally made more errors per session in the interlocking condition. Bobby did not consistently make fewer errors in either condition during Phase III but he did make consistently fewer errors in the interlocking condition during Phase IV.

Although figure 7 shows that Sidney did not consistently made more errors in one condition than in another during Phases I and II; figure 8 shows that the mean number of errors Sidney made over the last three-fifths of the sessions in each phase was higher in the interlocking condition than in the fixed-ratio condition. The mean number of errors Bobby made over the last three-fifths of the sessions in each phase was lower in the interlocking condition than in the fixed-ratio condition.

Ratio of Incorrect Responses to Response Opportunities

Figure 9 shows that, with Sidney, there was no consistent difference in the ratio of incorrect responses to response opportunities between the interlocking and fixed-ratio conditions during all four phases. This was also generally the case with Bobby during Phase I. However,

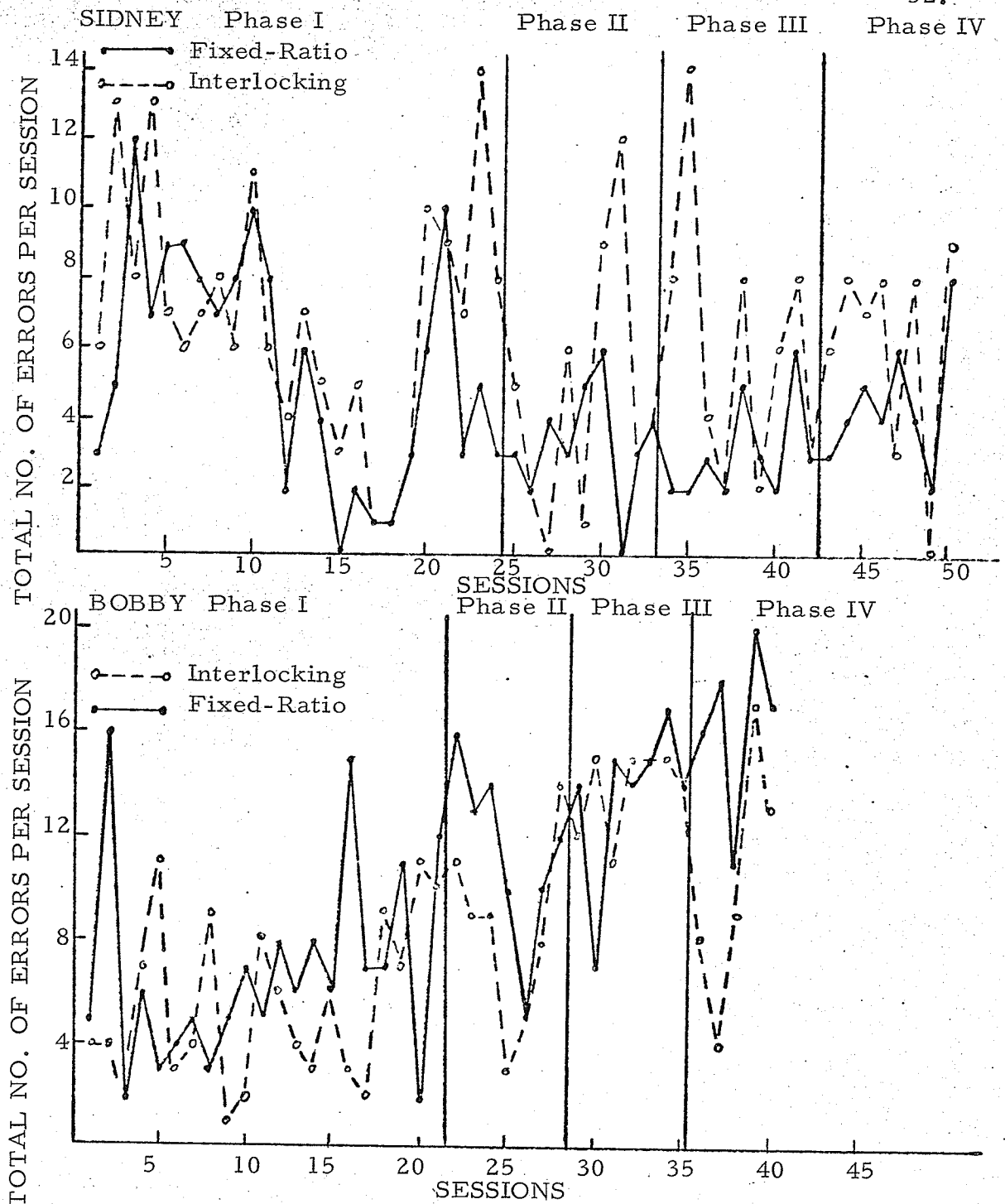


Fig. 7 The number of errors over all sessions in both experimental conditions for Sidney and Bobby. The values of the schedules of reinforcement in each phase are shown in the chart below.

SIDNEY				BOBBY			
Phase	Sessions	Schedule	Values	Phase	Sessions	Schedule	Values
		FR	Interloc.			FR	Interloc.
I	1-2	5	t=120	I	1-2	5	t=120
	3-5	5	t=80		3-5	5	t=70
	6-19	5	t=70		6-21	5	t=60
	20-24	5	t=60		II	22-28	8
II	25-33	8	t=60	III	29-35	5	t=60
III	34-42	5	t=60	IV	36-40	5	t=60
IV	43-50	5	t=30				

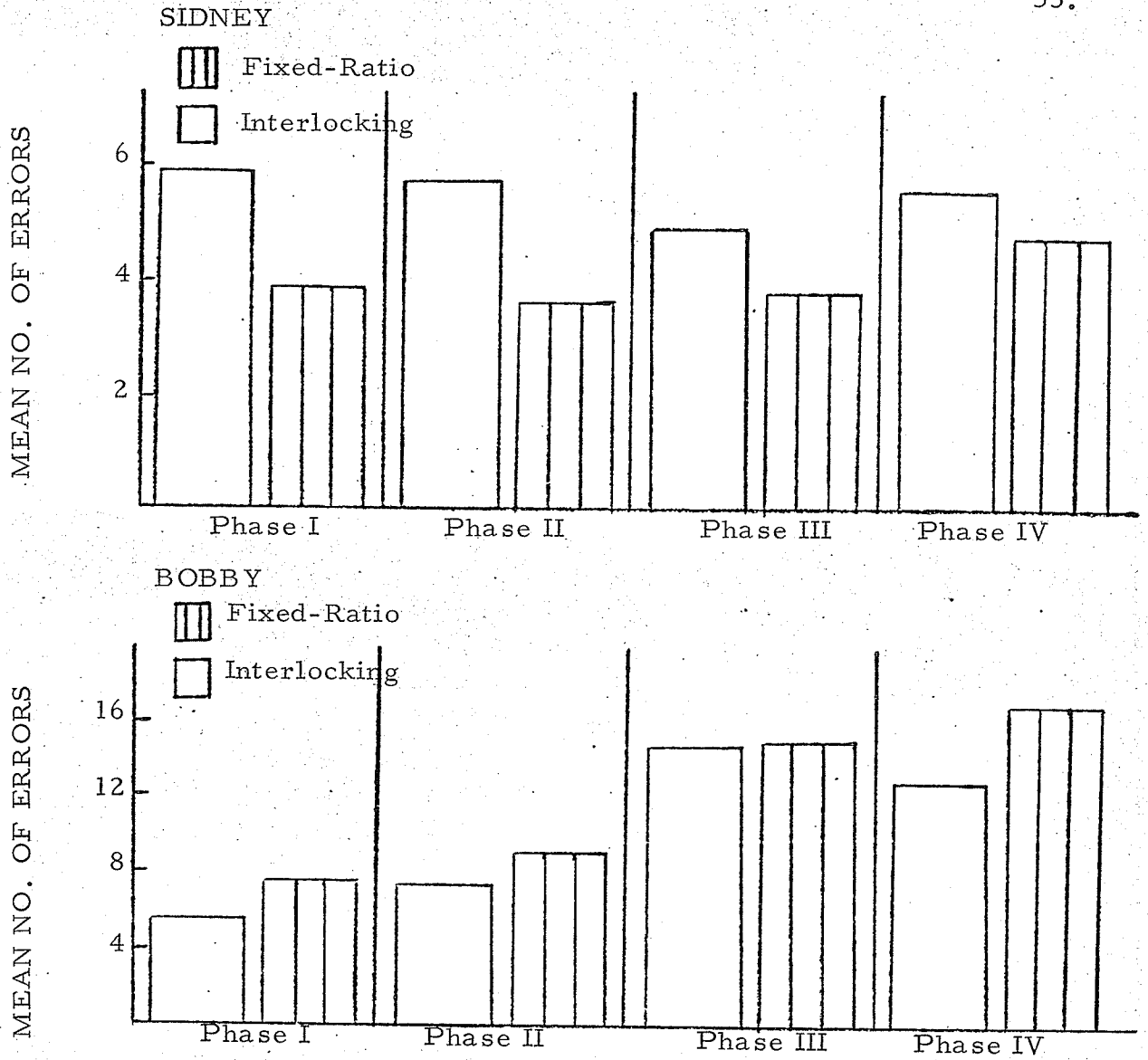


Fig. 8 The mean number of errors over the last 3/5 sessions of each phase of the experiment. The values of the schedule of reinforcement in each phase for each subject are shown in the chart below.

SIDNEY				BOBBY			
Phase	Sessions	Schedule	Values	Phase	Sessions	Schedule	Values
		FR	Interloc.			FR	Interloc.
I	1-2	5	t=120	I	1-2	5	t=120
	3-5	5	t=80		3-5	5	t=70
	6-19	5	t=70		6-21	5	t=60
	20-24	5	t=60	II	22-28	8	t=60
II	25-33	8	t=60	III	29-35	5	t=60
III	34-42	5	t=60	IV	36-40	5	t=30
IV	43-50	5	t=30				

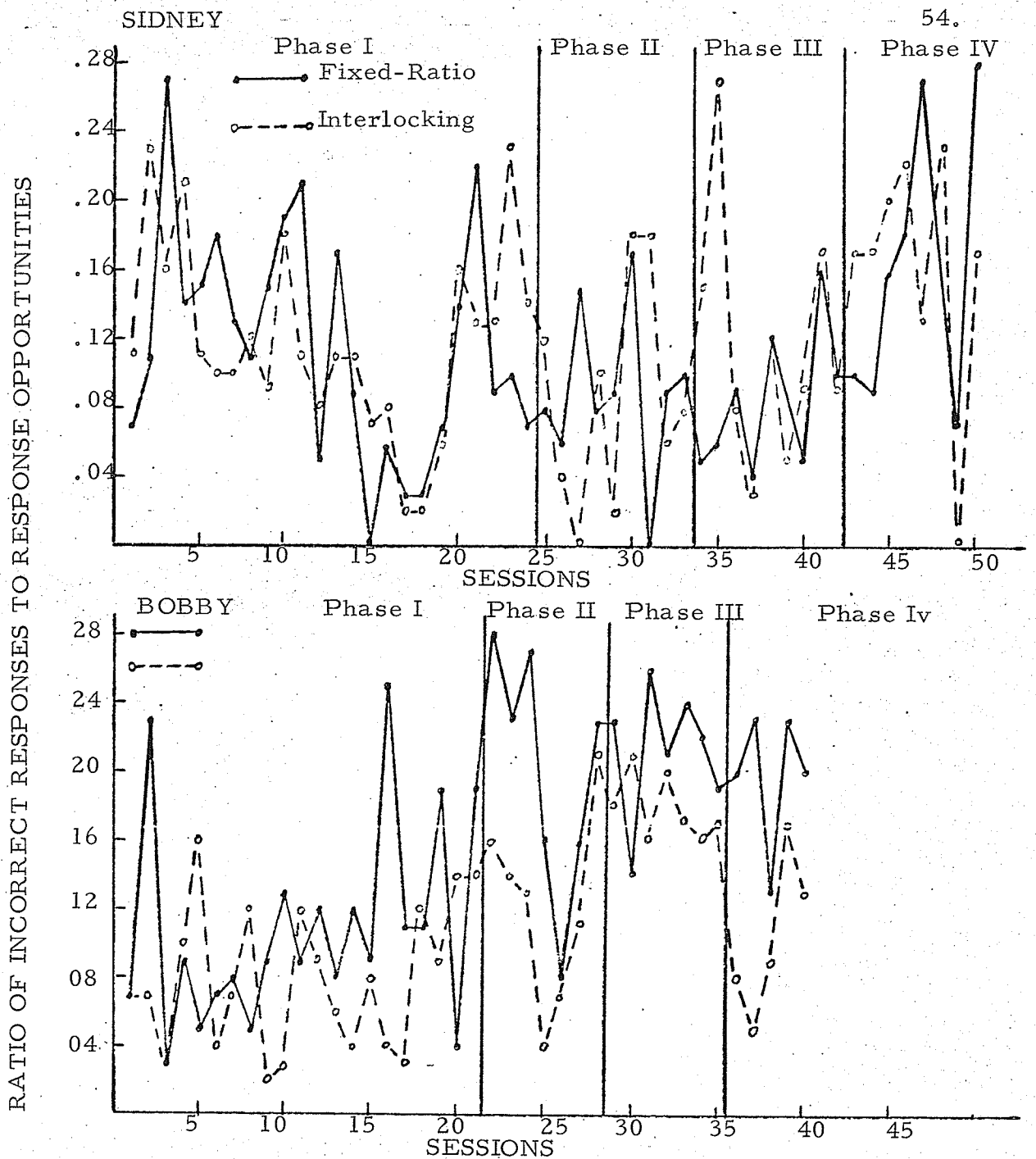


Fig. 9 The ratio of incorrect responses to response opportunities over all sessions for Bobby and Sidney in the Interlocking and Fixed-Ratio conditions. The values of the schedules of reinforcement in each phase are shown below.

SIDNEY				BOBBY			
Phase	Sessions	Schedule	Values	Phase	Sessions	Schedule	Values
		FR	Interloc.			FR	Interloc.
I	1-2	5	t=120	I	1-2	5	t=120
	3-5	5	t=80		3-5	5	t=70
	6-19	5	t=70		6-21	5	t=60
	20-24	5	t=60		II	22-28	8
II	25-33	8	t=60	III	29-35	5	t=60
III	34-42	5	t=60	IV	36-40	5	t=30
IV	43-50	5	t=30				

during Phases II-IV with Bobby, the ratio of incorrect responses to response opportunities was consistently lower in the interlocking condition than in the fixed-ratio condition.

Figure 10 shows that with Sidney, the mean of the ratio over the last three-fifths of the sessions was almost the same in both the interlocking and fixed-ratio conditions during the first three phases. In Phase IV there was an increase in the ratio of incorrect responses to response opportunities in both conditions as compared to Phase III. Figure 10 shows that from Phase I to Phase III with Bobby, the mean of the ratio of incorrect responses to response opportunities over the last three-fifths of the sessions increased in both conditions. In Phase IV the ratio decreased in both conditions as compared to Phase III.

Words Learned

Figure 11 shows that during Phase I Sidney learned to name the same number of pictures in each condition while Bobby learned to name more pictures in the interlocking condition. During Phase II both subjects learned more words in the interlocking condition than in the fixed-ratio condition. During Phase III Sidney again learned more words in the interlocking condition while Bobby learned the same number of words in both conditions. During Phase IV, figure 11 shows that for the first time, Sidney learned more words in the fixed-ratio condition than in the interlocking condition. Bobby learned more words in the interlocking condition during Phase IV.

MEAN RATIO OF ERRORS TO RESPONSE OPPORTUNITIES

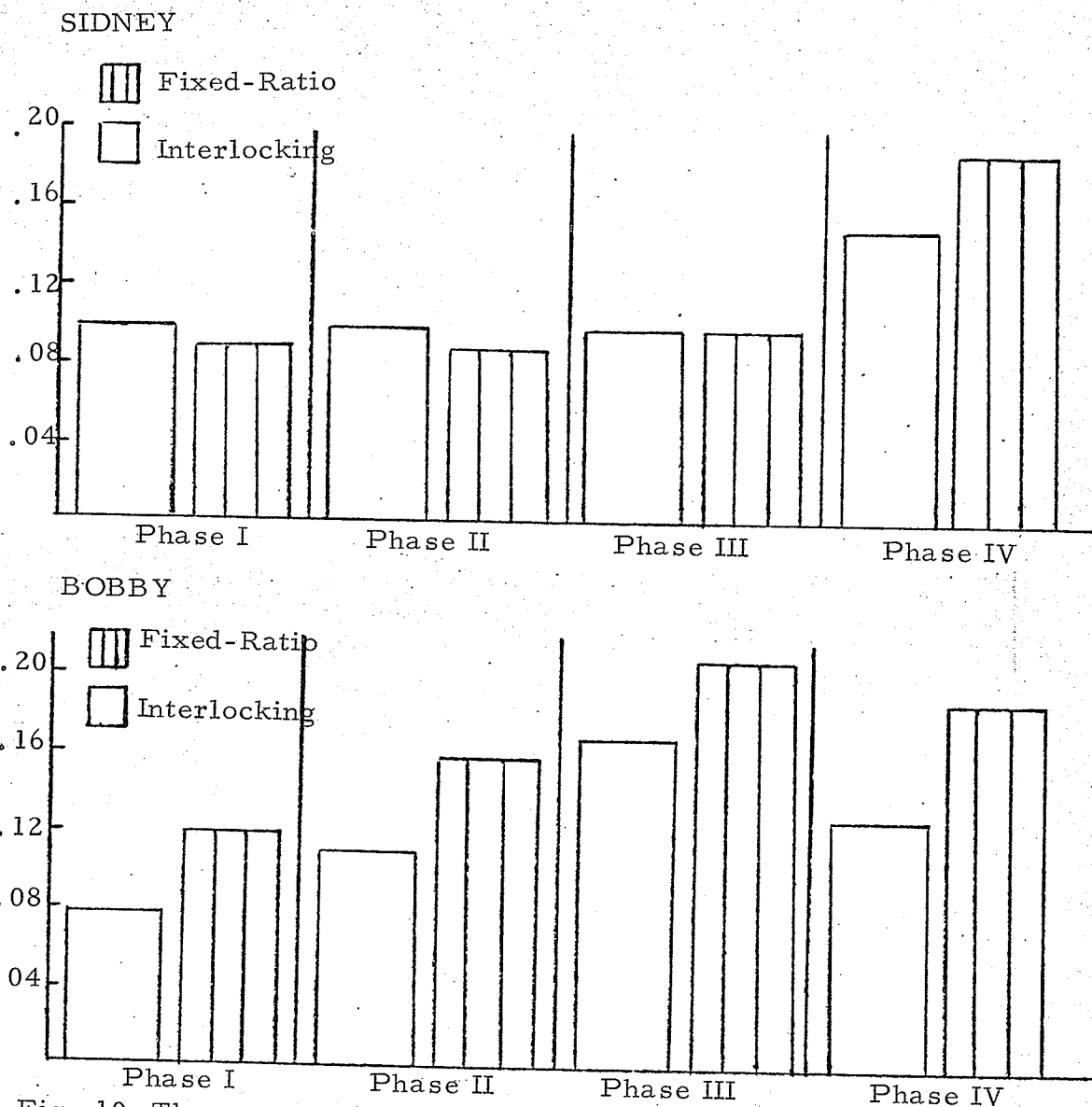


Fig. 10 The mean ratio of errors to response opportunities over the last 3/5 sessions of each phase. The values of the schedules of reinforcement in each phase are shown below.

SIDNEY				BOBBY			
Phase	Sessions	Schedule	Values	Phase	Sessions	Schedule	Values
I	1-2	FR	t=120	I	1-2	FR	t=120
	3-5	5	t=80		3-5	5	t=70
	6-19	5	t=70		6-21	5	t=60
II	20-24	5	t=60	II	22-28	8	t=60
	25-33	8	t=60	III	29-35	5	t=60
	34-42	5	t=60	IV	36-40	5	t=30
IV	43-50	5	t=30				

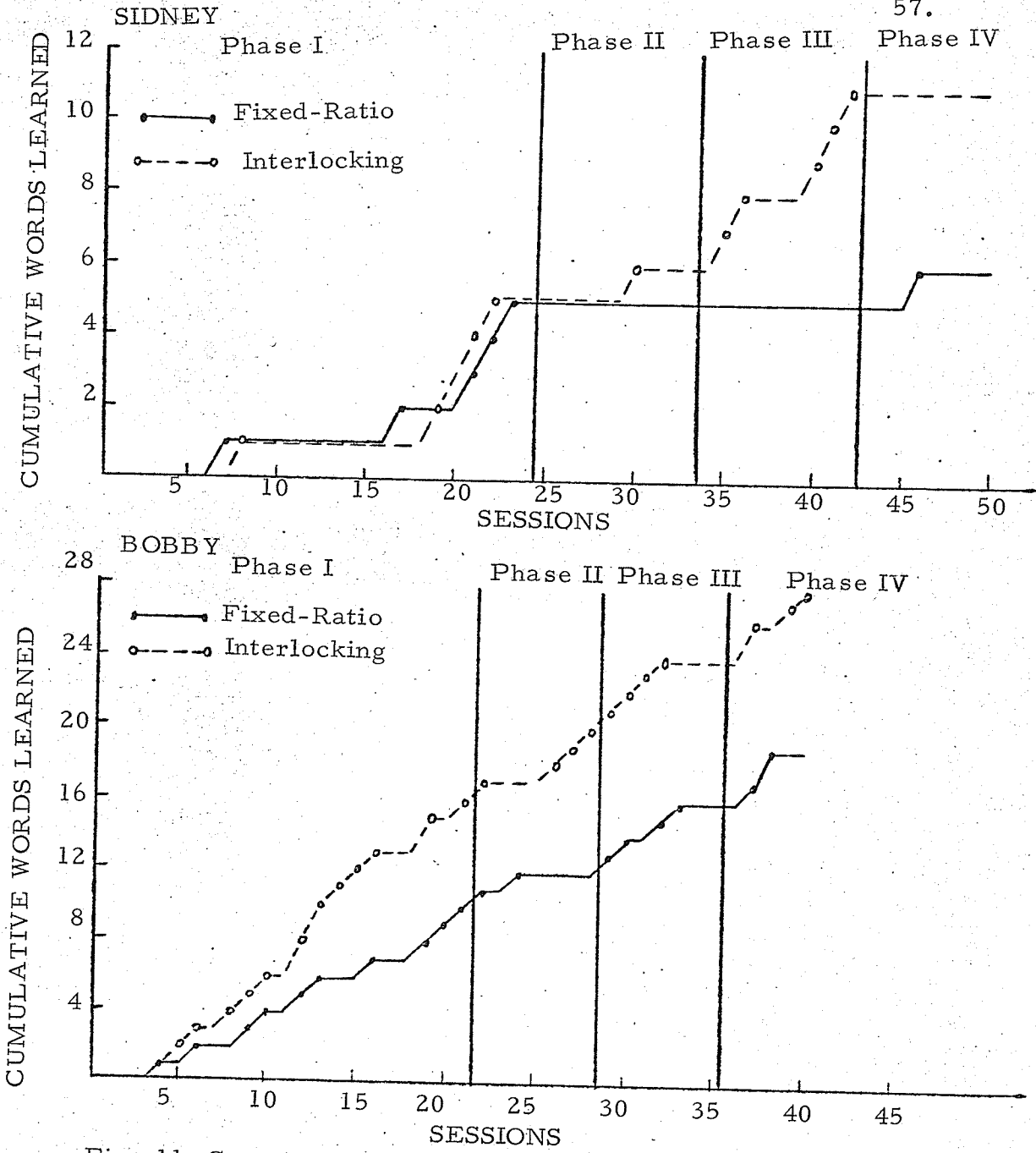


Fig. 11 Cumulative number of words learned over all sessions for Sidney and Bobby in the Interlocking condition and in the Fixed-Ratio condition. The values of the schedules of reinforcement in each phase are shown below.

SIDNEY				BOBBY			
Phases	Sessions	Schedule	Values	Phases	Sessions	Schedule	Values
		FR	Interloc.			FR	Interloc.
I	1-2	5	t=120	I	1-2	5	t=120
	3-5	5	t=80		3-5	5	t=70
	6-19	5	t=60		6-21	5	t=60
	20-24	5	t=60		II	22-28	8.
II	25-33	8	t=60	III	29-35	5	t=60
III	34-42	5	t=60	IV	36-40	5	t=30
IV	43-50	5	t=30				

Figure 12 shows that the rate of learning dropped in both conditions for both subjects during Phase II as compared to Phase I. During Phase III Bobby's rate of learning increased in the fixed-ratio condition, and Sidney's rate increased in the interlocking condition, as compared to the previous phase. During Phase IV Bobby's rate of learning increased in both conditions while Sidney's rate of learning increased in the fixed-ratio condition and decreased in the interlocking condition.

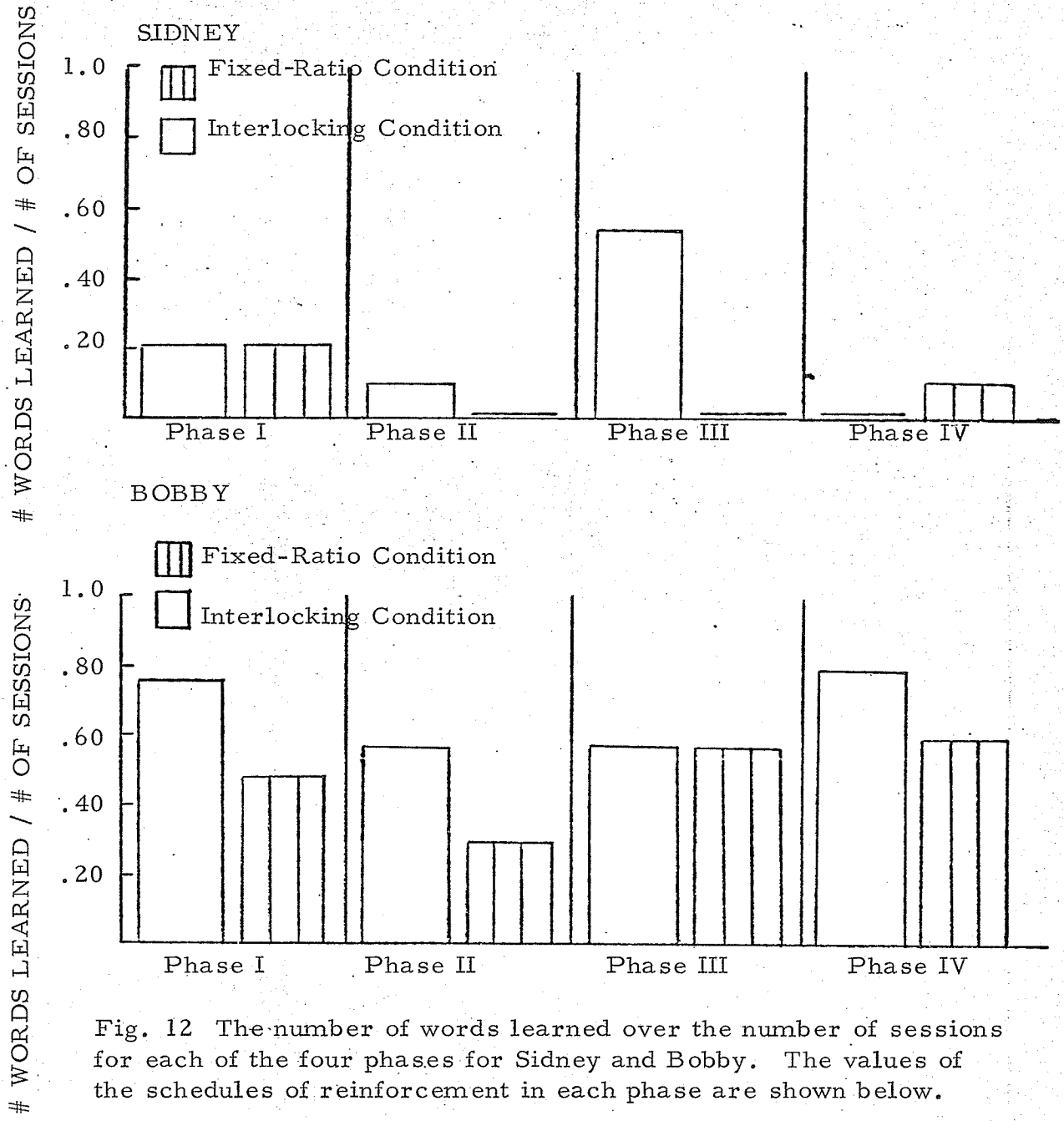


Fig. 12 The number of words learned over the number of sessions for each of the four phases for Sidney and Bobby. The values of the schedules of reinforcement in each phase are shown below.

SIDNEY				BOBBY			
Phases	Sessions	Schedule	Values	Phases	Sessions	Schedule	Values
		FR	Interloc.			FR	Interloc.
I	1-2	5	t=120	I	1-2	5	t=120
	3-5	5	t=80		3-5	5	t=70
	6-19	5	t=70		6-21	5	t=60
	20-24	5	t=60	II	22-28	8	t=60
II	25-33	8	t=60	III	29-35	5	t=60
III	34-42	5	t=60	IV	36-40	5	t=30
IV	43-50	5	t=30				

CHAPTER IV

DISCUSSION

In general the interlocking schedule seemed to produce a higher rate of picture-naming behavior than did the fixed-ratio schedule of reinforcement. Over all sessions Sidney learned 11 words in the interlocking condition and 6 words in the fixed-ratio condition. Bobby learned 28 words in the interlocking condition and 19 words in the fixed-ratio condition. The variables which were influenced most favorably by the interlocking schedule were inattentive time (Fig. 3), correct responses (Fig. 5), and words learned (Fig. 11). The interlocking schedule decreased the number of errors made with only one subject.

Throughout the experiment both subjects consistently emitted more correct responses in the interlocking condition than in the fixed-ratio condition (Fig. 5). Berryman and Nevin (1962) and Powers (1968) examined the effects of interlocking schedules of reinforcement in which the number of responses required for reinforcement decreased with the passage of time since the previous reinforcement. In this type of interlocking schedule the time base and the response base can be manipulated. They found that as the time base was lengthened, the response rate increased and as the response base was lengthened, the response rate decreased.

In the present research however it was found that as the time requirement was shortened, the number of correct responses emitted increased with Bobby (Fig. 5) and decreased with Sidney. An examination of this difference as a result of decreasing the time requirement, will illustrate the differences in the type of interlocking schedule of reinforcement used by Berryman and Nevin, and that used in this research. The interlocking schedule used by Berryman and Nevin was a combination of a fixed-interval (FI) schedule of reinforcement and a fixed-ratio (FR) schedule of reinforcement. As the time base is lengthened to infinity the schedule resembles a simple FR schedule and the highest rates of response were produced. As the response base is lengthened to infinity the schedule resembles a simple FI schedule and the lowest response rates were produced. At intermediate values between these extremes, intermediate rates of response were produced which were higher than those produced by the corresponding FI schedule and lower than those produced by the corresponding FR schedule. In the present research, however, the type of interlocking schedule used varies from a simple FR schedule to an extinction schedule (a schedule of reinforcement in which no responses are reinforced). As the time requirement is lengthened, the schedule resembled a simple FR schedule. As the time requirement is shortened, the schedule

resembles an extinction schedule. In the present research, intermediate values of this schedule seemed to produce response rates higher than those generated by a fixed-ratio schedule without the added temporal contingency. These results correspond with those found by Zeiler (1970). He added time limits to FR schedules of reinforcement such that pigeons were reinforced for key-pecking only if they took longer, or less than, a specified time to complete the ratio. He found, as was found with Bobby in the research, that shorter time criteria resulted in the ratio being completed faster (a higher response rate) than if there was no time criteria. This is only true within certain limits however, as verified by the decrease in the number of correct responses emitted by Sidney during Phase IV. It must be kept in mind then, that as the time requirement is shortened, the interlocking schedule resembles an extinction schedule more and more closely and at some point the behavior maintained by the interlocking schedule can be expected to deteriorate.

Although both subjects emitted more correct responses in the interlocking condition during Phase I, it was not possible to determine if this was a result of effects peculiar to the interlocking schedule of reinforcement. It could have simply been a result of more responses

being emitted per reinforcement during the interlocking condition than during the fixed-ratio condition. If this was the case, then the number of correct responses per session in the fixed-ratio condition should increase if the ratio was increased. Also, because the subjects typically received fewer reinforcements in the interlocking condition than in the fixed-ratio condition it could be argued that the greater number of correct responses per session in the interlocking condition was simply a result of more time being available to emit correct responses. Both of these possibilities were eliminated in Phase II by raising the response requirement of the fixed-ratio schedule of reinforcement. This resulted in almost the same number of reinforcements per session in each condition. As a result of this manipulation there was a decrease in the number of correct responses per session in both conditions for both subjects. When the response requirement was changed back to its Phase I value in Phase III, the number of correct responses increased in both conditions for Bobby and stayed about the same for Sidney. This would seem to indicate that the greater number of correct responses in the interlocking condition was not a result of more time being available or more responses being required for reinforcement. Shortening the time requirement of the interlocking schedule in Phase IV resulted in an increase in the number of correct responses Bobby emitted per session. This further emphasizes the fact that the greater number of correct responses in the interlocking

condition was due to effects peculiar to interlocking schedules. It could be mentioned at this point that the fact that changes in one schedule of reinforcement affected behavior in both conditions throughout the experiment suggests that the behavior in each condition may not have been under stimulus control.

Another variable which was favorably affected by the interlocking schedule was inattentive time (Fig. 3). Both subjects consistently spent less time engaging in inattentive behavior in the interlocking condition than in the fixed-ratio condition. Generally inattentive time seems to be a direct function of correct responses. If the number of correct responses increases, inattentive time must eventually decrease. Thus in most cases an increase in the number of correct responses was accompanied by a decrease in inattentive time. It is interesting to note however that both subjects spent less time engaging in inattentive behavior during Phases I, II, and IV in the interlocking condition, even though they were being reinforced less frequently in that condition and thus had more opportunities to engage in inattentive behavior in that condition than in the fixed-ratio condition.

This research indicated that the number of errors made was not as favorably affected by the interlocking schedule as was the number of correct responses (Fig. 7). Although Bobby generally made

fewer errors in the interlocking condition than in the fixed-ratio condition, Sidney usually made more errors in the interlocking condition. The ratio of errors to response opportunities was nearly the same in both conditions for Sidney throughout the experiment. Generally then it would seem that interlocking schedules can act selectively to increase correct responses and decrease errors but this isn't necessarily so. The interlocking schedule did not decrease the number of errors with Sidney, but proportionately it did not increase them either. Thus at worst, the interlocking schedule has no effects with respect to errors.

The difference in the effect of the interlocking schedule of reinforcement on errors and correct responses raises an important point. Part of the purpose of research such as this is to determine which variables should be employed in order to most efficiently establish certain behaviors, in this case picture-naming. But for many subjects such as Sidney, the most important variable, words learned, is not a very sensitive variable because over short periods of time not many words are learned. Thus differences in words learned often don't reliably indicate the superiority of one experimental condition as compared to another. This means that it is essential that we determine how other more sensitive variables are related to

words learned, so that we can determine the effectiveness of experimental manipulations with respect to relevant sensitive variables. This research indicates some interesting relationships between words learned, errors, and correct responses. It seems that correct responses are directly related to words learned. Both subjects learned more words in those conditions in which they emitted the most correct responses. On the other hand, incorrect responses was not consistently related to words learned. Sidney made more errors in the interlocking condition but learned more words in this condition. (Figs. 7 and 11). A learned word was defined as one which had reached criterion and been recalled on three successive sessions. It seems that the strength of the response on those occasions is directly related to the number of correct responses emitted previously. Both subjects were more likely to recall the names of pictures in those conditions in which they had emitted the most correct responses. If this is the case it would seem to indicate that we would more profitably spend our time looking for ways to increase correct response rate than looking for ways to suppress errors.

More research is needed to clarify the precise aspects of behavior affected by this type of interlocking schedule of reinforcement. More correct responses were emitted per session in the

in the interlocking condition than in the fixed-ratio condition even on occasions when inattentive time and number of reinforcements were nearly equal. This could be a result of a higher rate of response, a shorter post-reinforcement pause or a shorter latency between the presentation of a prompt or question and the subject's response. In order to clarify this a cumulative record of behavior would have to be kept and the latency of responses recorded.

The effects of fixed-ratio schedules of reinforcement in such procedures also need to be examined. Figure 5 indicates that even a small increase in the ratio of a fixed-ratio schedule can result in deterioration of the behavior. The behavior generated by ratio schedules in such tasks, from low fixed-ratios to high fixed-ratios, should be described. In a similar manner the behavior generated by this type of interlocking schedule should also be described for a number of values of the schedule and should be related to the effects of simple fixed-ratio schedules.

With regard to the use of such interlocking schedules in practical situations, some problems arise. One problem is that the automatic programming of such schedules requires the use of expensive and sophisticated equipment. This can be overcome however by simply having the experimenter make many of the decisions which were made

by the equipment in this experiment. The experimenter simply has to know the number of responses emitted and the amount of time that has passed in order to determine which response should be reinforced. This information could be provided with a minimum of equipment. The second problem is one which is common to all schedules of reinforcement; namely, what value of the schedule will be the most effective. At present this can only be determined by examining the effects of a number of different values on the behavior of interest. As more research is done it should be possible to make general statements as to those values which are likely to be most effective.

CHAPTER V

SUMMARY

The results of this study indicate that performance on a picture-naming task is generally superior under an interlocking schedule of reinforcement than under a fixed-ratio schedule of reinforcement. The variables most favorably affected by the interlocking schedule were inattentive time, correct responses, and words learned. The effects of the interlocking schedule could not be duplicated by increasing the requirement of the fixed-ratio schedule. It seems that within certain limits, decreasing the time requirement of the interlocking schedule results in an increased rate of response.

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