TEACHING TWO SIMPLE NON-VERBAL SYNTAXES TO TWO AUTISTIC CHILDREN

THESIS

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LIST OF ILLUSTRATIONS

Figure		Page
1.	Acquisition of Two-Term Relations in Order of Presentation	68
2.	Acquisition of Two-Term Relations in Order of Presentation	69
3.	Acquisition of Three-Term Relations in Order of Presentation	70
4.	Acquisition of Three-Term Relations	71
5.	Acquisition of Four-Term Relations	72
6.	Acquisition of Four-Term Relations	73
7.	Acquisition of Five-Term Relations	74
8.	Acquisition of Six-Term Relations	75
9.	Acquisition of Two, Three, and Four-Term Color Relations	76
10.	Acquisition of Shape Discriminations	76
11.	Syntax Acquisitions	77
12.	Syntax Acquisitions	78
13.	Acquisition of Syntax Discriminations	79
14.	Acquisition of Syntax Discriminations	80

INTRODUCTION

Surely language is the crown of humanity. It is at once the most unlikely and yet most utilitarian quality of human behavior. It delivers one from isolation; it is the foundation of humanity; it is the web-work in which all social organization is embedded. Language is a specifically human attribute. Language makes us men (Galanter, 1966).

No man, however low in the culture, was ever found to be without language. No animal, however high on the evolutionary scale, was ever found to possess anything approximating such a complex linguistic system. Language made man human, inasmuch as he could thereby think, reason, predict, and control all distinctly human activities (Thass--Thienemann, 1968).

The endlessly fascinating topic of language behavior and communication has been discussed, deciphered, and analyzed by scientists and theorists alike in an effort to understand man's symbolic system more fully. As a consequence, multitudes of theories evolved concerning man's acquisition of language, and the difference between the general system of language and human language in particular.

Advances during the past several years in the systematic study of language have stirred controversy, not only with respect to a number of complex issues in linguistic theory, but also in regard to the presumed bases for the entire process of language development. One group of parties to the controversy included those who endorsed the viewpoint of the generative approach to language. This group of theorists maintained that language acquisition as well as the human utterance were derived from the complex interactions between innate predispositions toward language acquisition and the stimulus inputs of his early social and linguistic environment. Thus, linguistic competence was construed as a neurological mechanism, whereas actual language behavior or performance was subject to a number of constraints such as motivation, memory, intelligence. The most articulate spokesman for this group was Noam Chomsky (Chomsky, 1956, 1957, 1967; Lenneberg, 1967).

The opposition, on the other hand, included those whose approach to the acquisition of language derived essentially from learning theory (Mowrer, 1960; Osgood, 1964; Skinner, 1967). Among this group was found a predilection for models which conceptualized language as a hierarchical structure of complex elements built up out of more simple constituents, reliance upon reinforcement, stimulus control, and mediated generalization as explanatory

principles accounting for the salient features of linguistic acquisition. Those constituents of the environment became the constellation of primary factors determining language acquisition and maintenance. Learning theorists obviously maintained that language behavior was a learned phenomenon. The development of that behavior was contingent upon the differential way in which the environment acted upon the individual's behaviors that produced and maintained language functions. The most articulate spokesman for this group was B. F. Skinner.

Perhaps it would have been more accurate to have said that the distinctions between the adherents of generative grammar, Chomsky and his group, and those who endorsed a view based on learning theory, Skinner and that group, involved some pervasive and deep-seated differences in philosophy of science, the dimensions of which were outside the limits of the present discussion.

However, what happened when a child failed to speak or respond to speech was clearly a question of human behavior, and hence a question to be answered with the concepts and techniques of psychology as an experimental science of behavior as contributed by Skinner, the final responsibility resting with the behavioral sciences.

The question which concerned all of the psychologists distinguished above was much more complex than whether or

not one "learned" a language. Obviously, everyone who spoke a language, English or Swahili, had to learn it at some time or another. It was assumed then, that one language code was as easily learned as another, the accepted medium being vocal language.

This accepted medium through which much of the accumulated knowledge and experience of our culture was transmitted and cultural patterns revolved, devoted few texts to the complex processes of non-vocal codification. Of those who have handled this subject, Ruesch spoke most articulately. Reusch (Smith, 1966), postulated three major categories of non-vocal codification: sign, action, and object language. Sign language included those forms of codification in which words were supplanted by gestures. They varied from the monosyllabic gesture of the hitchhiker to such complex systems as the language of the deaf. Action language comprised all movements that were not used exclusively as signals, e.g., walking and drinking. Object language included all intentional and nonintentional display of material things, such as machines, art objects, and the human body. Those three non-vocal means of communication differed with respect to the specific sensory modalities required for transmission.

Apart from these three types of non-vocal communication was the fourth, that of gesture language. Over the centuries,

every social group developed systems of communication in which particular words, signs, and gestures were assigned communicative significance. There were gestures that assumed the auxillary role of providing emphasis, timing, and direction. These gestures most assuredly cut across verbal language barriers in such a way that verbally coded messages could not penetrate the barriers. Communication by a system of sign language was almost exclusively human, i.e., other animals used a system of gestures, not a system of signs. Consequently, sign language dated back to the earliest history of the race itself.

Sign language was as much a real language as any other. The child who was born deaf would, obviously, have developed some communicative system with those around him derived in part from the visible part of the paralinguistic, and in part from the kinesic, communicative behavior of the culture (Trager, 1958). Based on the patterns of interactive behavior peculiar to that culture, the communication of the deaf-mute and his hearing companions developed in different ways from the normal community of the culture. Consequently, gesture behavior such as a shrug became more important and certainly more pronounced, even exaggerated, in the behavior of the deaf-mute, and perhaps also in that of his hearing partners in communication (Stokoe, 1960).

A cursory examination of the vocabulary of sign language for the deaf revealed some signs, the meaning of which was guessed by the uninformed observer, if the signaling occurred at a tolerant speed. The sign for book looked like a book being opened; it was, in a sense, an onomatopoetic sign, or it was said to have been cognate with the physical visualization of the object it named. Of course, most of the other signs when signed were as obstruse and incomprehensible to the naive observer as any unknown linguistic quality.

The sign language also had a high potential for the creation of occasional signals, signs that came into being in a discursive situation and then passed out of existence once the situation or a particular statement made in the situation came to an end. Those nonce-signs appeared at first glance to be neologisms, but neologizing activity, in sign language discourse, had to be weighed differently from the same phenomenon in English. The aspectral nature of language, the relative magnitude of the organs of communication (fingers, hands, arms, upper body), and the factor of simultaneity, there were no sequential syllables, made possible for the immediate inversion of a nonce-sign. Nonce signs were immediately understood by users of the sign language and were not looked upon as being neologistic (Mendelson, 1964).

Although the analysis of the grammar and syntax for the sign language was still in the initial stages, certain basic patterns were observed. There was a tendency for the most important constituent in a whole signed statement to occur initially. From the standpoint of linguistics, this was accounted for by the absence of audible parameters of vocalization that controlled antecedent parts of a spoken sentence until the gist was delivered by the speaker. Viewed psychologically, the phenomenon of antiperiodicity in signed statements might have been attributed to the shorter duration of visual perseveration as compared to the relatively long duration of auditory perseveration.

Sign language was economical and rapid, so that it could be executed or read three times as quickly as articulated speech. It was potentially graceful and pleasing to the eye, and a wide range of expressive or facial movements could accompany and enrich the manual signs in a manner which was supremely eloquent.

The sign language of deaf-mutes possessed its own primitive syntax. Definite and indefinite articles were usually omitted, adjectives and verbs were not easily distinguished. The tenses were not differentiated unless the meaning of the phrase absolutely demanded this. The order of words was logical rather than in conformity with local grammatical construction.

As deaf people communicated, their attention was focused on the face. They did not look at the hands. The face was the focal point. Therefore, it carried most of the burden of enriching the meaning of signs and finger spelling. It must have become automatic for an individual signing "bad" to, at the same instant, have had a deep furrowed frown on his face, or if the meaning indicated, a raised and questioning eyebrow. Facial expressions were not just amusing and entertaining, they were as vital to expression as any other signaling reflex.

Organisms lower on the phylogenetic scale than man were capable of some rather intricate and elaborate patterns of non-vocal communicative behavior, too. One would surely consider the "body-language" of the honeybee as a striking example of non-vocal signaling activity. The studies of the German naturalist, Von Frisch (1955), have shown that bees were able to convey location and direction of food discoveries to others in the swarm by means of a series of maneuvers as stylized, in some respects, as the fugures in classical ballet.

Von Frisch constructed a hive with glass walls that permitted him to observe the behavior of the bee tenants when they returned from a food-seeking flight. When the source of nectar was close, within 100 feet or less, the finder bee would perform a "dance" consisting of a circular

movement. To indicate longer distances, the bee would run in a straight line while moving its abdomen rapidly from side to side, then make a turn and repeat the maneuver. For distances in excess of 200 yards, the number of turns made by the bee decreased. A run followed by only two turns, for example, might have indicated that the food source was several miles away.

After observing this behavior, the other bees were able to fly directly to the food. It was apparent that they received cues to the location of the food from the direction of the "run" made by the finder bee. An upward vertical run in the hive indicated that the food source would be found by flying into the sun, whereas a downward vertical run indicated that the food source was away from the sun. Von Frisch found that bees which were restricted to a horizontal surface and deprived of sunlight were unable to communicate the direction of their finds.

Outside of the non-vocal signals of the bees, the most promising infrahuman candidate for vocal communication honors, the exception to the rule having been the primate, was the bottle-nose dolphin or porpoise. Equipped with a brain that was larger than the human brain, the dolphin demonstrated some amazing capacities for complex learning. In addition, it possessed an elaborate and variegated set of soundmaking capabilities. From the respiratory blowhole in its head, the dolphin produced both whistles and

a sound that was likened to a "raspberry" or Bronx cheer. It could also produce a series of clacks by gnashing its needle-pointed teeth. But its chief soundmaking apparatus was a voice box that compared in complexity with human vocal equipment. From this voice box, it could emit a tremendously complicated range of barks, squawks, whistles, mewings, creakings, and other sounds that were more difficult to identify. They ranged from deep bass to a supersonic pitch far beyond the limits of human auditory receptivity.

Dr. John Lilly of the Communications Research Institute of Miami, Florida, was acknowledged to be one of the world's foremost authorities on dolphin behavior. Dr. Lilly was convinced after more than a decade of research that dolphins were capable of not only intelligent communication but even of language. One of his more startling findings was that dolphins appeared to possess mimetic capabilities. By reducing the playback speed of a tape recorded dolphin vocalizations, Lilly found that he could distinguish sounds that resembled a baby crying, human laughter and other sounds one normally associated with human beings (Lilly, 1966). Thus far, Dr. Lilly had not succeeded in establishing the type of linguistic communication between himself and his aquatic subjects that confirmed even more modest expectations of their vocal capacities. Evidence is not yet complete.

Infrahuman human communication was an interesting and absorbing subject in its own right, apart from the question of its possible relevance to the understanding of language. Nearly every species that had been studied had revealed a capacity for communication, and this ability to communicate was a vital aspect of the forms of social organization these animals developed. However, no example that could be cited displayed the deliberate and intelligent use of symbols that characterized human language behavior.

Klineberg pointed out (1954), the main difference between human language and that of all other animals seemed to lie mainly in the fact that the language of animals could express only what was present at the time. It occurred mainly in response to an emotional situation. As far as one could tell, however, it had no abstract or symbolic meaning, nor could it describe to any extent, what had happened in the past or what would have happened in the future. The twofold capacity for time-binding and abstraction was generally regarded as an indispensable property of human language.

Of more direct relevance to language problems were the studies conducted by David Premack (1972) using the chimpanzee. Premack sought to clarify the dividing line between the general system of language, vocal or non-vocal, and the uniquely human form of language behavior.

Premack considered the chimpanzee a good candidate for the acquisition of language on the basis of an extensive vocal "call system" the animal possessed in their natural environment, their ability to sort pictures into classes when taught in captivity, and the animal's ability to classify the same item in different ways depending on the alternatives offered, also taught in captivity. On the basis of these demonstrated capabilities, it was assumed that the chimpanzee could be taught not only the names of specific members of a class but also the names for the classes themselves. It was not necessary for the names to be vocal. They could just as well be based on gestures, written letters, or colored stones. In this case, however, colored plastic shapes were used instead of stones, letters, or gestures.

In the first stage, Premack taught a five year old chimpanzee, Sarah, to put only one colored plastic shape on a magnetic board when shown a particular fruit. The name of the fruit was sufficient to obtain the piece of fruit. When verbs for different actions were introduced, Sarah had to place two words on the board in vertical sequence. In order to be given a banana, she had to place the symbols for "Give banana" on the board. When recipients were named, two-word sentences were not accepted by the trainer. Sarah was required to use three words. There

were several trainers and the chimp had to learn the name of each one. To facilitate the teaching of personal names both the chimpanzee and the trainers wore their plastic word names on a string necklace.

At every stage, Sarah was required to observe the proper word sequence. "Give banana" was accepted, but "Banana give" was not accepted. When donors were to be named, Sarah had to identify all the members of the social transaction: "Mary give banana Sarah."

As a preliminary to learning the class concepts of color, shape, and size, Sarah was taught to identify members of the classes red and yellow, round and square, large and small. Objects that varied in most dimensions that had a particular property in common were used. Thus, for teaching the word "red," a set of dissimilar, unnamed objects, a ball, a toy, and so on, that had no property in common except redness were put before the chimpanzee. The only plastic work available was "red." After several trials on identifying red with a set of red objects and yellow with a set of yellow objects, Sarah was shifted to trials where she had to choose between "red" and "yellow" when she was shown a colored object. Finally, completely new red and yellow objects were presented to her, including small cards that were identical except for their color.

Sarah was subsequently taught the names of shapes, "round" and "square," as well as the size names "large"

and "small." These words formed the basis for teaching her the names of the class concepts "color of," "shape of," and "size of." In teaching class names, a good many sentences were not written on the board but were presented as hybrids. The hybrid sentences consisted of a combination of plastic words and real objects arranged in the proper sentence sequence on the magnetic board.

Sarah's behavior with hybrid constructions recalled the activity of young children, who sometimes combined spoken words with real objects they were unable to name by pointing at the objects.

Sarah had managed to learn a code, a simple non-vocal language that nevertheless included some of the characteristic features of what Premack referred to as "natural language." The objective was to reduce complex notions to a series of simple and highly learnable steps. The same program that was used to teach Sarah to communicate had been successfully applied with people who had language difficulties caused by brain damage.

It appeared reasonable that the same program could be employed with the autistic child. Often assessed as "retarded" in most of the usual areas of normal skills, the autistics were in times past commonly labeled "retarded." They may not have had speech, and if they could speak, their speech may have been limited in a variety

of ways. They usually had little or no ability to read or write, the usual common skills the normal child had in his expressive or receptive repertoires. Motor difficulties ranged from slight in nature to grosser uncoordination typical of organic involvement. Few of these children had relationships with other children or adults. Many of them have displayed various psychotic symptoms, particularly compulsive ritualistic actions and behavior resembling hallucinations as studied by Hubert Coffey and Louise Weiner, (1967).

Autistic children did not have the physical stigmata of the Mongoloid child or other such retarded children. Many of them were often considered beautiful by the standards of our culture, but often their behaviors were as primitive and constricted as the retardate. Many of them demonstrated no affection, and seemed as untouchable as the leper of rabinical days. A fair share of clinitians who have worked with this particular population have felt discouraged when reviewing the outcome of studies employing psychotherapy (Lovaas, O., Kassorla, Irene, 1966). It was in fact apparent that psychotherapy was quite useless in the amelioration of self-destructive behavior, echolalic speech, and self-stimulating behavior such as rocking, finger manipulation and the like.

In the past it was generally accepted that in order to explain such bizarre behavior, one must have attributed it

to events taking place inside the child. Consequently, in the area of verbal behavior, if the child was silent as in autism, it must have been a deficiency in ideas, intelligence quotient, or the inability to put those ideas into words. If he spoke haltingly, it was a result of poor internal organization of words and so on. All properties of verbal behavior were accounted for in this manner. Properties of the child could not be dealt with adequately when they were unempirical and without definition. The alternate approach was to distinguish behavior of all kinds from activities which were primarily concerned with the internal economy of the child or person. The alternate approach was to break down the behavior in question into its variables or functions of its particular variables.

The following study had been developed to demonstrate language behavior in subjects that matched or demonstrated deficient language behavior like Sarah's (Premack, 1971). Two autistic children were selected as subjects. These two subjects demonstrated that children who could not normally fulfill the language behavior requirement of selecting specific words, letters, or colored stones, and arranging them in some good temporal sequence, could in fact be taught to do just that activity. In this manner, language deficient candidates more severely

damaged than the subjects used by Premack in his study on language difficulties in persons who were "brain damaged," could be taught the parameters of syntax and semantics on a non-vocal level, and thereby fulfill the criterion for language behavior, namely that of arranging specific symbols in good temporal sequence.

The following study was designed to demonstrate the acquisition of syntactic and semantic behavior in two six year old nonverbal autistic children.

Method

Subjects

The subjects were two autistic children, one male and one female. Parental reports stated that the little girl demonstrated normal growth and development until approximately age two. Prior to age two, the child had been able to use and say three words fairly appropriately. She had also developed the major motor skills for her age group. As the little girl grew older, it was apparent that the normal progression of forming more sounds and word units into syntactical units, or sentences, had failed to occur. Shortly thereafter, the subject lost all speech and was essentially nonverbal when she was first seen at the Center for Behavioral Sciences where the current study was conducted.

This lack of verbal behavior automatically indicated gross receptive and expressive repertoire problems. The child had no attention span and consequently could not understand, follow, or even imitate simple commands. Her behavior was not under good enough control at the time of the initial interview for one to clearly evaluate the depth of her behavioral deficits and problems.

The subject had visited many professionals prior to her arrival at the clinic, and was variously diagnosed autistic, retarded, brain damaged, and neurologically damaged.

The second subject was a little boy also six years old. According to parental reports, this child had developed normally up to about age two and one half. At that time, he could repeat or parrot a few words and could make additional sounds. He was, however, unable to use the few words he could repeat effectively or productively. No sentences and no new sounds were forthcoming at the time of arrival at the Center for Behavioral Sciences. The child was extremely hyperactive, running about the room during the initial interview, screaming and mumbling upon occasion. Attention was nonexistant, and his expressive and receptive repertoires were grossly impaired.

At the time of the initial interview, this subject was evaluated as being nonverbal and uncommunicative. The

most remarkable feature about this subject was the fact that his motor skills were normal.

Apparatus

A 10 x 4 inch wooden form board was used to hold the objects in the match-to-sample portion of the program, Program I, and was later used to hold the cardboard symbols employed in the syntactic and semantic training. The objects included the following: a regular sized silver spoon, a small white doll's plate, a small two inch white cup, a pink infant sock, a red two inch ball, and a one inch black button. The shapes used in the match-to-sample procedure included the following flat, planar, three inch, yellow cardboard shapes: a circle, a square, a triangle, and an L-shape. The colored cardboard squares used in the same procedure were the following: a blue three inch square, a green one, a yellow one and a red one, all with the same dimensions.

Several different symbols were used in the syntactic and semantic training, Programs II and III. They were the following three inch blue cardboard symbols: a heart symbolizing the man doll, a right triangle symbolizing the preposition "on," a diamond symbolizing a chair, a circle symbolizing the woman doll, and a square symbolizing the boy doll. The corresponding colors used in Program III

were the following three inch squares: orange representing the heart, blue representing the right triangle, pink representing the diamond, red representing the circle, and purple representing the square. The apparatus for both Program I and II also included three four inch plyable dolls and one two inch plastic chair.

Reinforcers included small sips of Coke and small bits of chocolate candy or "Captain Crunch."

Procedure

The procedure was divided into three programs. Program I was designed to teach the subjects to select a similar stimulus object from a variety of dissimilar objects. This procedure is commonly called match-to-sample.

Three varieties of stimuli were employed as matching samples. These were common objects (ball, spoon, cup, etc.), geometrical cardboard shapes, and colors mounted on identical cardboard backings.

Six common objects, ball, spoon, cup, sock, button, and plate; four geometrical shapes, circle, square, triangle, and L; and four colors, red, yellow, green, and blue were included.

The population of objects from among which the subject was to choose one similar to the sample presented him

increased systematically in number. Initially, only one object was employed, thus insuring that the subject would make a correct matching response since none but the object appropriate to the sample was present.

For example, the subject was shown a spoon and required to select from the table the only object present, the spoon. No other objects were on the table with the spoon. If the subject made a selection response within three seconds after prompted, the response was recorded as correct for that trial. Hesitation beyond three seconds, dawdling, or otherwise failing to make a discreet selection response was recorded as an incorrect trial. All correct responses were reinforced with bits of candy. All incorrect responses were not reinforced, although a correction procedure, involving picking the subject's hand up and moving it to make the correct response, was employed.

When the subject responded correctly at least nine out of ten times, the arbitrary criterion was reached and another object was selected. Similarly, the procedure was enacted until a criterion of nine of ten correct consecutive trials were achieved. All of the six common objects were introduced in this fashion and trained to criterion.

In the next step, the object to be selected appropriate to the sample was presented along with another object

dissimilar to the sample. For example, the cup and the spoon were placed on the table before the subject and he was shown the spoon (matching sample). A response was correct if the spoon was selected within the time requirement. This having been achieved, the dissimilar object of the two in the matching population became the new matching sample. The cup was presented as the matching sample and the subject was required to select the proper object from the two objects before him (cup and spoon). This procedure was continued alternating the spoon and the cup until nine consecutively correct responses were made in a ten trial block.

The following discriminations were taught in the same fashion: spoon-plate, spoon-button, spoon-ball, spoon-sock, cup-button, cup-ball, cup-sock, cup-plate, plate-button, etc., until all of the combinations for those six objects taken two at a time were completed.

The number of objects in the matching population was increased to include a third object. All possible variations of matching samples and matching population combinations were trained to criterion.

After the successful completion of the three object matching, the subject was taught to select from among four objects, five objects, and at last six objects. Ultimately, the subject could select the appropriate object

from among the six object population sample, and match appropriately to any sample object presented.

The six object selection was the placing of all six objects on the board after having taken each one of the six objects individually in training, until nine trials were completed correctly out of ten trials. Then, all six objects were combined and the subject was required to match correctly at random, any one of the six objects shown to the subject by the experimenter.

In the second part of Program I, the subject was taught to match to a sample color. The colors used were red, green, blue, and yellow.

The subject was to place a red card on the form board when shown a red card by the experimenter. Each of the four colors were treated in the same fashion, until the subject had placed each color nine out of ten trials correctly on the board.

Correct responses were dependent upon the selection of the correct color within a three second period. Any other response within that three second time limit was considered to be incorrect and was recorded as such. All two color discrimination sets were taught in the same fashion, using red-blue, red-green, red-yellow, blue-green, blue-yellow, yellow-green, until all of the possible combinations had been taught, and the standard criterion measure completed.

Thus, essentially, the same procedure was followed with the colors as with the objects. After learning to match to all four colors and select from the sample populations of two, three, and four colors, the subject reached a point where he could match to any color from the full population, and do so to criterion.

The same procedure as employed with objects and colors, was employed with the four geometrical shapes. The ultimate skill the subject demonstrated was the ability to respond to any of the four matching forms by selecting the appropriate similar form from among the full compliment of four matching forms on the table before him.

Program I was essential in teaching the subjects the match-to-sample procedure, but was far more important in giving the subjects experience with different populations as well. It was a necessary step in the overall study in as much as the subjects needed all the discriminations possible in order to perform the tasks required later for the other two programs. Moving too quickly had a disasterous effect upon later discriminations.

Program II was designed to teach the subjects to select three geometrical shapes from a maximum of five available shapes before him, and to place these three shapes in the appropriate order on the form board. Appropriateness of shapes selected and the order they were

to be placed on the form board were cued by the model presented at the beginning of each trial. Models consisted of three toy dolls (man, woman, and boy), and a small toy plastic chair of comparable size to the human dolls. The five geometrical shapes employed were a heart, circle, square, triangle, and a diamond.

The population of geometrical forms from among which the subject was to choose and place in order corresponding to the model presented, increased systematically in number. Initially, only three forms were employed, insuring that the subject could not fail to select the correct geometrical shape. In addition, the order in which the three shapes were presented was initially correct, thus calling for a correct arrangement. The subject's response at the onset was to merely transfer the three objects in the same order from the table to the form board.

In the first series, the subject was shown the model of the toy man doll seated on the chair. The subject was required to select from the table the only forms present, heart-triangle-diamond, and to transfer these in the same order to the form board. If the subject made an appropriate selection response within three seconds after prompted, the response was recorded as correct for that trial. Hesitation beyond three seconds, otherwise failing

to make a discreet selection response was recorded as an incorrect trial.

When the subject responded correctly at least nine out of ten trials, he reached the criterion measure and another order of the same forms was selected, requiring the subject to transfer the order of the forms from that on the table, and to place them in the correct order on the form board.

When the three forms were to be selected, three at a time and placed on the form board, it was obvious that six different orders could result. For example, if as in the current situation, a heart, triangle, and diamond were considered, the following six orders would result when placed in horizontal order from left to right.

heart-triangle-diamond
heart-diamond-triangle
triangle-heart-diamond
triangle-diamond-heart
diamond-heart-triangle
diamond-triangle-heart

In general, the number of orders or permutations, "n" objects taken "r" at a time was given by the formula $\frac{n!}{(n-r)!}$. In the case above, there were three objects taken three at a time, or $\frac{3!}{(3-3)!} = \frac{3!}{0}$ $3 \cdot 2 \cdot 1 = 6$

It was deemed necessary to train the subjects to make the proper response from any permutation of the forms presented him. Thus each of the six orders were learned

sequentially to criterion. The subject could ultimately look at the man doll sitting on the chair and arrange the forms correctly on the form board from any one of the six possible arrangements presented on the table before him.

When the subjects reached the criterion measure, another toy model, a woman seated on a chair was introduced. This new model required the deletion of the geometrical form corresponding to man, heart, from the forms placed before the subject and the replacement by a new form, a circle corresponding to the new object or toy model, namely a woman.

As with the forms for the previous model, heart-triangle-diamond, which corresponded to man-on-chair, there were six different orders in which the circle, triangle, and diamond could be presented to the subject prior to his opportunity to respond. As with the man-on-chair model, it was necessary to give the subject experience with each of the six orders and to train to criterion on them. Ultimately, both subjects could respond to any ordering of the forms by transferring them to the correct representation when placed on the form board.

The third model, a boy doll on the toy chair, was introduced and along with it, a new geometrical form corresponding to boy, a square. The three forms, square-triangle-diamond, corresponding to boy-on-chair, were

learned to criterion for each of the six possible orders of presentation. The procedure was thus exactly comparable to the other two models presented earlier.

In the next step, additional forms were added to the display presented to the subject. These two forms were irrelevant to the model, but did require the subject to select from among four and then later five geomentrical forms.

Applying the general formula once again $\frac{n!}{(n-8)!}$, it was seen that the possible orders of six, when three objects were taken three at a time, increased when four objects were taken three at a time to 24, and increased to 60 when five objects were taken three at a time, i.e., $[\frac{4!}{(4-3)!} = \frac{4!}{1!} = 4 \cdot 3 \cdot 2 = 24]$, $[\frac{5!}{(5-3)!} = \frac{5!}{2!} = 5 \cdot 4 \cdot 3 = 60]$. The discriminations that the subject had to make became dramatically more difficult as new forms were included in those forms among which selection could take place.

For example, heart, circle, triangle, and diamond were placed on the table before the subject, and he was shown the man doll seated on the chair model. A response was correct if the unit heart-triangle-diamond was selected within the time requirement. This procedure was continued until nine consecutively correct responses were made in a ten trial block.

The remaining two models, boy-on-chair and woman-on-chair, were learned to criterion with the four form permutations as selection alternatives.

The number of forms in the matching population was then increased from four to five forms. The subject was required to respond to each of the three models by choosing the appropriate forms from the population of five before him, heart, circle, triangle, square, diamond, and placing them in the proper order on the form board.

After the successful completion of this step, the subject could ultimately select and arrange the appropriate forms from among five forms in the selection population and arrange them in the proper sequence corresponding to whatever model was presented to him.

Program III was designed to teach the subjects to select and arrange three colors, mounted on identical cardboard backings, from a population of colors placed before him. The appropriateness of his response was judged in terms of the constituencies of an arrangement of geometrical shapes presented as a model. The colors used were red, orange, blue, pink, and lavendar, the same colors he had learned to match to sample in Program I.

The subject was to sequentially select the colors and arrange them in the proper order from the model presented by the experimenter. The model included one of the three

syntactical unit learned in Program II in response to toy models depicted, man-on-chair, woman-on-chair, and boy-on-chair. It will be recalled that the corresponding geometrical sequences relevant to these toy models were heart-triangle-diamond, circle-triangle-diamond, and square-triangle-diamond.

In the initial trials of Program III, the subject was shown the geometrical sequence heart-triangle-diamond, and was required to select the colors orange-blue-pink. At this initial stage, only three colors were present and were arranged left to right in the correct order. The subject's response was a simple one, involving a transfer of the colors from the table to the board, retaining the same order. If this response was made within three seconds, the subject was reinforced and the trial was recorded as correct. Hesitation beyond three seconds, or otherwise failing to make a discreet selection response, constituted an incorrect response and was not reinforced.

Responding correctly at least nine of ten trials was considered criterion. Once the criterion measure was reached, the three colors were presented in a different order and the same procedure was enacted. The subject was required not only to transfer the colors to the form board, but to rearrange them in the correct order as well. When criterion was reached, another order was presented, and so on, until all six possible orders had been mastered to criterion.

Ultimately, the subjects were able to select and arrange the colors in an order corresponding to the geometrical forms presented as a model when the colors were presented in any of the six possible orders.

Next, another syntactical unit comprised of the geometrical forms, circle-triangle-diamond, and corresponding to the relationship, woman-on-chair, Program II, was introduced. The subjects were required to select three colors, red-blue-pink, and place them in the correct order on the form board. As with the previous model of geometrical forms, the three colors were presented in each of the six possible orders and learned to criterion.

The third model of geometrical forms was introduced, square-triangle-diamond, which corresponded to boy-on-chair. Again, three colors were introduced, lavendar-blue-pink, and the subject required to arrange them in the proper order on the form board. Each of the six possible orders of presentation for the three colors were learned to criterion.

At this point, the subjects could respond correctly to all three models of geometrical forms by arranging the three appropriate colors in the proper order on the form board. An additional color was added, orange, for the subjects to select from among for colors. This increased the number of possible orders from six to twenty-four.

The subjects were trained to criterion for each of the twenty-four orders, and for all three models.

The non-relevant color added, orange, was deleted, and replaced with a new non-relevant color, red. Thus, the color population remained at four colors, allowing the twenty-four orders of four colors. The subjects were trained to criterion on each order, and for each of the three models of geometrical forms.

In the final phase of Program III, the subjects were required to select the three colors to be placed on the form board from among all five colors. The possible orders that five objects could assume was mathematically computed to be sixty. However, it was not considered necessary to train the subjects on each of these orders. Only five orders were chosen. Training to criterion proceeded immediately. Each of these five orders was then randomly presented. Since both subjects were demonstrating essentially errorless performances, trials involving spot checking of several orders of the possible sixty orders were enacted. Results were encouraging in that neither subjects had difficulty in making the correct arrangement.

At the termination of Program III, the subjects were competent to choose the appropriate three colors representing any of the three model geometrical forms, and do

so, by making the selections from the population of five colors presented in any possible order.

Results

Program I: Match-To-Sample--Objects

Each discrimination problem was terminated and a new one begun whenever the subjects achieved nine of ten consecutive trials correct. Thus, data recorded for each portion of the study was the number of trials attempted before criterion was reached, trials to criterion.

Trials to criterion for both subjects, on match-to-sample data for a single object matching population, where the only object in the matching population was the same as the sample, i.e., spoon as the sample population, spoon on the table, and for a two object matching population, where two objects were presented, one dissimilar to the matching sample, i.e., spoon as the sample, spoon and cup on the table, were presented in Figures 1 and 2. Also presented in Figures 1 and 2 were the trials to criterion data for the alternation series where the subjects were given a two term-matching population and each object in the population became the matching sample on the alternate trials, i.e., spoon and cup in matching populations, spoon presented as the matching sample on trial number one, cup presented on trial number two as the matching sample,

spoon presented again as the matching sample on trial number three, etc.

Figure four presented the trials to criterion data on match-to-sample discriminations for three-term matching populations, i.e., cup, spoon, button, and for alternations where each of the three objects were alternated as the matching sample.

Figures 5 and 6 depicted the trials to criterion on the match-to-sample discriminations for four-term matching populations, i.e., cup, spoon, button, ball, and for alternation series where each of the objects were alternated as matching samples.

Figures 7 and 8 presented the same general relationships for five-term matching populations, i.e., spoon, cup, button, ball, plate, and for alternation series.

Figure 8 also depicted data for six-term matching populations, i.e., spoon, cup, button, ball, plate, sock, and for alternation series.

Program I: Match-To-Sample--Colors

Four colors were employed in this portion of the study. They were red, green, yellow, and blue. The subjects were introduced to match-to-sample problems where the population from which the match was to be selected increased systematically as the criterion was reached on previous problems, and alternation series of the previous elements also were

mastered to criterion. Thus, the sequence was as follows: red as a matching sample; red as a matching population; green as a matching sample; red and green as the matching population; alternation of red and green as a matching sample; red and green as the matching population; red as the matching sample; red as the matching population; yellow as the matching sample; red and yellow as the matching population; alternation of red and yellow as the matching sample; red and yellow as the matching population. The sequence continued as follows: red as the matching sample; red as the matching population; blue as the matching sample; red and blue as the matching population; alternation of red and blue as the matching sample; red and blue as the matching population; yellow as the matching sample; yellow as the matching population; green as the matching sample; yellow and green as the matching population; alternation of yellow and green as the matching sample; yellow and green as the matching population; green as the matching sample; green as the matching population; blue as the matching sample; green and blue as the matching population; alternation of green and blue as the matching sample; green and blue as the matching population; yellow as the matching sample; yellow as the matching population; blue as the matching sample; yellow and blue as the matching population; alternation of yellow and blue as the

matching sample; yellow and blue as the matching population.

All two-term relations were depicted on Figure 9 along with the following three-term relations: red as the matching sample; red as the matching population; green as the matching sample; green as the matching population; yellow as the matching sample; red, green and yellow as the matching population; green as the matching sample; green as the matching population; yellow as the matching sample; yellow as the matching population; blue as the matching sample; green, yellow, blue as the matching population; alternation green, yellow, blue as the matching sample; green, yellow, blue as the matching population; and blue as the matching sample; blue as the matching population; red as the matching sample; red as the matching population; green as the matching sample; blue, red, green as the matching population; alternation blue, red, green as the matching sample; blue, red, green as the matching population.

The last series of discriminations depicted in Figure 9 was that series for a four-term relation. Thus the sequence was as follows: blue as the matching sample; blue as the matching population; red as the matching sample; red as the matching population; yellow as the matching sample; yellow as the matching population; green

as the matching sample; blue, red, yellow, green as the matching population; alternation of blue, red, yellow, green as the matching sample; blue, red, yellow, green as the matching population.

Program I: Match-To-Sample--Geometrical Forms

Four geometrical forms were employed in this portion of the study. They were square, circle, triangle, and L. The subjects were introduced to the match-to-sample problems where the population from which the match was to be selected increased systematically as the criterion was reached on previous problems, as alternation series of the previous elements were mastered to criterion. Thus, the sequence was as follows: square as the matching sample; square as the matching population; triangle as the matching sample; square and triangle as the matching population; alternation square and triangle as the matching sample; square and triangle as the matching population; square as the matching sample; square as the matching population; L as the matching sample; square and L as the matching population; alternation square and L as the matching sample; square and L as the matching population. This process was continued until all combinations of two-term relations had been trained. The remaining two-term relations included the following:

circle-triangle, square-circle, triangle-L, and circle-L as depicted in the first graphs at the top of Figure 10.

The two graphs of Figure 10 depicted the production of the syntactical parameter of three-term relations for this segment of Program I. The first three-term relation was taught and recorded in the following manner: square as the matching sample; square as the matching population; triangle as the matching sample; triangle as the matching population; circle as the matching sample; square, triangle, circle as the matching population; alternation of square, triangle, circle as the matching sample; square, triangle, circle as the matching population. This procedure continued until all possible three-term relations had been considered. They included the following sets: square, triangle, L; square, circle, L; and circle, L, triangle.

The last series of discriminations depicted in two graphs at the bottom of Figure 10 was that series for a four-term relation. The sequence was as follows: square as the matching sample; square as the matching population; triangle as the matching sample; triangle as the matching population; circle as the matching sample; circle as the matching population; L as the matching sample; square, triangle, circle, L as the matching population; alternation square, triangle, circle, L as the matching sample; and square, triangle, circle, L as the matching population.

Program II: Geometrical Forms in Syntactical Sequences.

The data for Program II were recorded in Figure 11 for three geometrical forms employed in the first six permutations. The subjects were shown the first model (man-on-chair). The first permutation was transferred to the form board as it appeared before subjects; heart-triangle-diamond. The second permutation as it appeared before the subjects on the table was triangle-diamond-heart. The subjects were to rearrange these three geometrical forms and transfer them to the form board in the correct sequence, heart-triangle-diamond. The third, fourth, fifth and sixth permutations appeared on the table before the subjects in the following order:

heart-diamond-triangle
diamond-heart-triangle
triangle-heart-diamond
diamond-triangle-heart

The subjects rearranged each one of the orders, transferring the correct arrangement, heart-triangle-diamond, to the form board before the six permutations were alternated and a new syntactic unit was introduced. The second sequence of geometrical forms introduced in Figure 11 was circle-triangle-diamond. The second permutation of the series to be presented to the subjects appeared on the table in the order triangle-diamond-circle. The subjects were to rearrange these three geometrical forms

and transfer them to the form board in the correct sequence, circle-triangle-diamond. The permutations presented thereafter appeared on the table before the subjects in the following orders:

diamond-circle-triangle
triangle-circle-diamond
circle-diamond-triangle
diamond-triangle-circle

The subjects rearranged each one of the orders, transferring the correct order, circle-triangle-diamond, to the form board before the six permutations were alternated and a new syntactic unit, square-triangle-diamond, was introduced.

The subjects were introduced to the last model, boy-on-chair. The first permutation was transferred to the form board as it appeared before the subjects, square-triangle-diamond. The remaining five permutations were presented to the subjects in the following order:

triangle-diamond-square
triangle-square-diamond
square-diamond-triangle
diamond-square-triangle
diamond-triangle-square

The subjects arranged each permutation, transferring the correct arrangement, square-triangle-diamond, to the form board. Thus, all six permutations were eventually alternated until the criterion measure was fulfilled.

In the next step, the subjects reviewed the random presentations of the six orders for heart-triangle-diamond. They also reviewed the random presentations for the six orders for circle-triangle-diamond, before training was initiated for the twenty-four permutations involving the selection and arrangement of three geometrical forms from among the four.

At this point, the subjects were required to arrange the three appropriate geometrical forms in the proper order on the form board from among four available forms, heart, circle, triangle and diamond. This increased the number of possible orders from six to twenty-four. The twenty-four permutations were divided into four groups, each group containing six permutations.

The first groups of six permutations began with the geometrical form corresponding to man, heart. The subjects attended to the model being presented and made the appropriate response, i.e., selecting the correct symbols and arranging them on the form board in the appropriate sequence.

The first permutation, as it appeared before the subjects on the table, was heart-circle-triangle-diamond. The subjects were to select the appropriate geometrical forms, arrange them, and transfer them to the form board. The permutations presented thereafter appeared on the table before the subjects in the following order:

heart-triangle-circle-diamond
heart-triangle-diamond-circle
heart-circle-diamond-triangle
heart-diamond-circle-triangle
heart-diamond-triangle-circle

The subjects selected and rearranged each one of the orders, transferring the correct order, circle-triangle-diamond or heart-triangle-diamond, to the form board, depending upon the model presented, before those six permutations were alternated and the second group of permutations was introduced.

The second group of permutations began with the geometrical form corresponding to woman, circle. The subjects attended to the model being presented, man-on-chair or woman-on-chair. The six permutations presented in this group appeared before the subjects in the following order:

circle-heart-triangle-diamond
circle-triangle-heart-diamond
circle-triangle-diamond-heart
circle-heart-diamond-triangle
circle-triangle-heart-diamond
circle-diamond-heart-triangle

The subjects selected and rearranged each permutation to criterion, transferring the correct arrangement, heart-triangle-diamond or circle-triangle-diamond, to the form board. Thus, all six permutations in this group were trained to criterion before they were alternated in a random presentation. Data recorded for this group were presented in the last graph of Figure 11.

The identical procedure was repeated for the last two groups of permutations, one group beginning with the geometrical form triangle, the last group beginning with the form diamond.

The permutations for the third group were presented in the following order:

triangle-circle-diamond-heart
triangle-diamond-circle-heart
triangle-diamond-heart-circle
triangle-circle-heart-diamond
triangle-heart-circle-diamond
traingle-heart-diamond-circle

The fourth group of permutations was presented to the subjects in the following order:

diamond-circle-heart-triangle
diamond-triangle-heart-circle
diamond-triangle-circle-heart
diamond-circle-triangle-heart
diamond-heart-triangle-circle
diamond-circle-heart-triangle

The subjects selected and arranged each permutation, transferring the correct arrangement, heart-triangle-diamond or circle-triangle-diamond, to the form board. Thus, all six permutations for each group were trained to criterion before they were alternated in a random presentation. Data recorded for these groups were presented in Figure 11, last graph, and Figure 12, the first graph.

In the next phase of Program II, the subjects reviewed the random presentations for the geometrical syntaxes

circle-triangle-diamond and square-triangle-diamond before training was initiated for the last twenty-four permutations.

At this point, the subjects were required to arrange the three appropriate geometrical forms in the proper order on the form board from among four available forms, circle-square-triangle-diamond.

The twenty-four permutations for these geometrical forms were divided into four groups, each group containing six permutations.

The first group of permutations began with the geometrical form corresponding to boy, square. The subjects attended to the model being presented, and made the appropriate response, i.e., selecting the correct symbols and arranging them on the form board in the appropriate sequence. The first permutation, as it appeared before the subjects on the table, was square-circle-triangle-diamond. The subjects were to select the appropriate geometrical forms, arrange them and transfer them to the form board. The permutations presented thereafter appeared on the table before the subjects in the following order:

square-circle-triangle-diamond
square-triangle-circle-diamond
square-triangle-diamond-circle
square-circle-diamond-triangle
square-diamond-circle-triangle
square-diamond-triangle-circle

The subjects selected and rearranged each one of the orders, transferring the correct order, circle-triangle-diamond or square-triangle-diamond, to the form board, depending upon the model presented, before those six permutations were alternated and the second group of permutations was introduced.

The second group of permutations began with the geometrical form corresponding to woman, circle. The subjects attended to the model being presented. The six permutations presented in this group appeared before the subjects in the following order:

circle-square-triangle-diamond
circle-triangle-square-diamond
circle-triangle-diamond-square
circle-square-diamond-triangle
circle-triangle-square-diamond
circle-diamond-square-triangle

The subjects selected and rearranged each permutation to criterion, transferring the correct arrangement to the form board. Thus all six permutations in this group were trained to criterion before they were alternated in a random presentation. Data recorded for this group were presented in Figure 12.

The identical procedure was repeated for the last two groups of permutations, one group beginning with the geometrical form triangle, and the last group beginning with the form diamond.

The permutations for the third group were presented in the following order:

triangle-circle-diamond-square
triangle-diamond-circle-square
triangle-diamond-square-circle
triangle-circle-square-diamond
triangle-square-circle-diamond
triangle-square-diamond-circle

The fourth group of permutations was presented in this order:

diamond-circle-triangle-square
diamond-triangle-circle-square
diamond-triangle-square-circle
diamond-circle-square-triangle
diamond-square-circle-triangle
diamond-square-triangle-circle

The subjects selected and arranged each permutation, transferring the correct arrangement to the form board. Thus, all six permutations for each group were trained to criterion before they were alternated in a random presentation.

In the last phase of Program II, the subjects reviewed the random presentations for the geometrical syntaxes heart-triangle-diamond, circle-triangle-diamond, square-triangle-diamond, before training was initiated for the last five discriminations.

At this point, the subjects were required to arrange the three appropriate geometrical forms in the proper order

on the form board from among five available forms, heart-circle-square-triangle-diamond.

Five permutations were chosen to be trained to criterion instead of the mathematically computed sixty permutations.

These five permutations were presented in the following order:

square-heart-circle-triangle-diamond
heart-circle-triangle-diamond-square
circle-heart-square-triangle-diamond
triangle-diamond-circle-heart-square
diamond-triangle-circle-square-heart

The subjects selected and arranged each permutation to criterion, transferring the correct arrangement to the form board. A random presentation of these five orders was trained to criterion at the end of Program II.

Program III: Colors in Syntactic Sequences

The data for Program III were recorded in Figure 13 for the three colors employed in the first six permutations. The subjects were shown the geometrical forms heart-triangle-diamond. The first permutation, orange-blue-pink, was transferred to the form board as it appeared before the subjects. The second permutation, as it appeared on the table before the subjects, was blue-pink-orange. The subjects were to rearrange these three colors and transfer them to the form board in the correct sequence, orange-blue-

pink. The third, fourth, fifth, and sixth permutations appeared on the table before the subjects in the following order:

blue-orange-pink
orange-pink-blue
pink-orange-blue
pink-blue-orange

The subjects rearranged each one of the orders, transferring the correct arrangement, orange-blue-pink, to the form board before the six permutations were alternated and a new syntactic unit was introduced.

The second sequence of colors introduced in Figure 13 was red-blue-pink, having six possible orders of presentation. The subjects were shown the geometrical forms circle-triangle-diamond. In response to the model, the subjects transferred first permutation to the form board, as it appeared on the table, red-blue-pink. The second permutation of the series to be presented to the subjects appeared on the table in this order: blue-pink-red. The subjects were to rearrange these three colors and transfer these to the form board in the correct sequence, red-blue-pink.

The permutations, thereafter, appeared on the table before the subjects in the following order:

pink-red-blue
blue-red-pink
red-pink-blue
pink-blue-red

The subjects rearranged each one of the orders, transferring the correct order, red-blue-pink, to the form board before the six permutations were alternated and a new syntactic unit, lavendar-blue-pink, was introduced.

The subjects were introduced to the last color sequence, lavendar-blue-pink. The subjects were shown the geometrical forms square-triangle-diamond. In response to the model, the subjects transferred the first permutation to the form board as it appeared on the table, lavendar-blue-pink. The remaining five permutations were presented to the subjects in the following order:

blue-pink-lavendar
blue-lavendar-pink
lavendar-pink-blue
pink-lavendar-blue
pink-blue-lavendar.

The subjects rearranged each permutation, transferring the correct arrangement, lavendar-blue-pink, to the form board. Thus, all six permutations were eventually alternated until the criterion measure was fulfilled.

In the next step, the subjects reviewed the random presentations of the six orders for orange-blue-pink. They also reviewed the random presentations of the six orders for red-blue-pink, before training was initiated for the twenty-four permutations involving the selection and arrangement of three colors from among four.

At this point, the subjects were required to arrange the three appropriate colors in the proper order on the form board from among four available colors, orange, red, blue, and pink. This increased the number of possible orders from six to twenty-four. The twenty-four permutations were divided into four groups, each group containing six permutations.

The first group of six permutations began with the color corresponding to the geometrical symbol heart. The subjects attended to the model being presented, either heart-triangle-diamond or circle-triangle-diamond. The appropriate response was made, i.e., selecting the correct colors and arranging these on the form board in the appropriate sequence.

The first permutation, as it appeared before the subjects on table, was orange-red-blue-pink. The subjects were to select the appropriate colors, arrange them, and transfer them to the form board. The permutations presented thereafter appeared on the table before the subjects in the following order:

orange-blue-red-pink
orange-blue-pink-red
orange-red-pink-blue
orange-pink-red-blue
orange-pink-blue-red

The subjects selected and rearranged each one of the orders, transferring the correct order, orange-blue-pink or red-blue-pink, to the form board before those six permutations were alternated and the second group of permutations was introduced.

The second group of permutations began with the colors corresponding to the geometrical form circle. The subjects attended to the model being presented, heart-triangle-diamond or circle-triangle-diamond. The six permutations presented in this group appeared before the subjects in the following order:

red-orange-blue-pink
red-blue-orange-pink
red-blue-pink-orange
red-orange-pink-blue
red-blue-orange-pink
red-pink-orange-blue

The subjects selected and rearranged each permutation to criterion, transferring the correct arrangement, orange-blue-pink or red-blue-pink, to the form board. Thus, all six permutations in this group were trained to criterion before they were alternated in a random presentation. Data recorded for this group were presented in the last graph of Figure 13.

The identical procedure was repeated for the last two groups of permutations, one group beginning with the color blue, the last group beginning with the color pink.

The permutations for the third group were presented in the following order:

blue-red-pink-orange
blue-pink-red-orange
blue-pink-orange-red
blue-red-orange-pink
blue-orange-red-pink
blue-orange-pink-red

The fourth group of permutations were presented to the subjects in the following order:

pink-red-orange-blue
pink-blue-orange-red
pink blue-red-orange
pink-red-blue-orange
pink-orange-blue-red
pink-orange-red-blue

The subjects selected and arranged each permutation, transferring the correct arrangement, orange-blue-pink or red-blue-pink, to the form board. Thus, all six permutations for each group were trained to criterion before they were alternated in a random presentation. Data recorded for these groups were presented in Figure 13.

In the next phase of Program III, the subjects reviewed the random presentations for the color syntaxes red-blue-pink and lavendar-blue-pink, before training was initiated for the last twenty-four permutations.

At this point, the subjects were required to arrange the three appropriate colors in the proper order on the form board from among four available colors, red-lavendar-blue-pink.

The twenty-four permutations for these colors were divided into four groups, each group containing six permutations.

The first group of permutations began with the colors corresponding to square, lavendar. The subjects attended to the model being presented, and made the appropriate response, i.e., selecting the correct symbols and arranging these on the form board in the appropriate sequence. The first permutation, as it appeared before the subjects on the table, was lavendar-red-blue-pink. The subjects were to select the appropriate colors, arrange them, and transfer these to the form board. The permutations presented thereafter appeared on the table before the subjects in the following order:

lavendar-red-blue-pink
lavendar-blue-red-pink
lavendar-blue-pink-red
lavendar-red-pink-blue
lavendar-pink-red-blue
lavendar-pink-blue-red

The subjects selected and rearranged each one of the orders, transferring the correct order, red-blue-pink or lavendar-blue-pink, to the form board before the six permutations were alternated and the second group of permutations was introduced.

The second group of permutations began with the colors corresponding to the geometrical form circle, red. The

subjects attended to the model being presented. The six permutations presented in this group appeared before the subjects in the following order:

red-lavendar-blue-pink
red-blue-lavendar-pink
red-blue-pink-lavendar
red-lavendar-pink-blue
red-pink-blue-lavendar
red-pink-lavendar-blue

The subjects selected and rearranged each permutation to criterion, transferring the correct arrangement to the form board. Thus, all six permutations in this group were trained to criterion before they were alternated in a random presentation. Data recorded for this group were presented in Figure 14.

The identical procedure was repeated for the last two groups of permutations, one group beginning with the color blue, and the last group beginning with the color pink.

The permutations for the third group were presented in the following order:

blue-red-pink-lavendar
blue-pink-red lavendar
blue-pink-lavendar-red
blue-red-lavendar-pink
blue-lavendar-red-pink
blue-lavendar-pink-red

The fourth group of permutations were presented in this order:

pink-red-blue-lavendar
pink-blue-red-lavendar
pink-blue-lavendar-red
pink-red-lavendar-pink
pink-lavendar-red-pink
pink-lavendar-pink-red

The subjects selected and arranged each permutation, transferring the correct arrangement to the form board. Thus, all six permutations for each group were trained to criterion before they were alternated in a random presentation.

In the last phase of Program III, the subjects reviewed the random presentations for the color syntaxes orange-blue-pink, red-blue-pink, and lavendar-blue-pink, before training was initiated for last five permutations.

At this point, the subjects were required to arrange the three appropriate colors in the proper order on the form board from among five available colors, orange, red, lavendar, blue, pink.

Five permutations were chosen to be trained to criteria instead of the mathematically computed sixty permutations.

These five permutations were presented in the following order:

lavendar-orange-red-blue-pink
orange-red-blue-pink-lavendar
red-orange-lavendar-blue-pink
blue-pink-red-orange-lavendar
pink-blue-red-lavendar orange

The subjects selected and arranged each permutation to criterion, transferring the correct arrangement to the form board. A random presentation of these five orders was trained to criterion at end of Program III.

Discussion

Program I was designed to teach the subjects to select two similar stimulus objects (geometrical form or color) from a variety of dissimilar objects (geometrical forms or colors) a match-to-sample procedure.

Six common objects, cup, spoon, ball, sock, button, and plate; four geometrical shapes, circle, square, triangle, and L; and four colors red, blue, yellow, green were included.

The subjects could ultimately select the appropriate matching object, geometrical shape, or color from among the matching objects, geometrical shapes, and colors placed on the table before him.

Program I was designed to teach the subjects to select the matching common object, geometrical form, or color in a match-to-sample procedure. The results from the discrimination training of six common objects demonstrated that both subjects began to make errorless discriminations with two-term relations after experience

with less than three sets (spoon and ball) by matching the appropriate object from among two objects and placing it on the form board when presented with one of the objects.

The first set of three-term relations showed some variations in fifteen trials to criterion. For subject one indicating the transition for subject was somewhat difficult at first. Subject two showed no difficulty in moving from two-term relations to three-term relations. As experience with three-term relations progressed, both subjects were making errorless discriminations, demonstrating a mastery of three-term relations as training progressed.

Errorless discrimination continued throughout four-term, and five-term relations with only occasional variation which was accounted for in terms of competing extraneous behavior. At the termination of this phase of Program I, both subjects select the appropriate object from among the six object population sample, and watch appropriately to any sample object presented within the criterion measure without any hesitation or apparent difficulty.

The second phase of Program I employed the same match-to-sample procedure using colors instead of common objects. Subject two required more trials to criterion in the training of the first five sets of two-term

relations while subject one made errorless proficiency for the first sets of two-part discriminations; the fourth set of discriminations involving the color yellow in the set yellow/green required fifteen trials to criterion. Subjects continued to have difficulty with the color yellow throughout the three-term relations involving the color yellow. Subjects began to make errorless discriminations with the two-term relations after the training of the three set with slight variation on two occasions during the three-term relation sets as a result of the competing behavior, head-turning.

By the termination of this phase of Program I, both subjects had learned to match any color from the sample populations of four colors, and do so to criterion.

In the last phase of Program I, geometrical forms replaced the colors and objects. Both subjects demonstrated immediate errorless discrimination for two, three, and finally four-term discriminations. No variation was recorded for any of the sets. As a result, both subjects demonstrated without error the ability to respond to any of the four matching forms by selecting the appropriate similar form from among the full compliment of four matching forms.

As in Premack's study (1971) with the chimp, Sarah, the subjects, as well as Sarah, could be taught to identify

members of certain classes of stimuli including color, shape, similarity, or size. It was not necessary for the names of the specific members of a class to be vocal. They could be based on gesture, letters, or colored forms.

The language function taught to Sarah by David Premack was a semantic system consisting of discriminations of four colors eventually leading to the fulfillment of a syntactic system; the production of the arrangement of symbols or colors.

In Program I, two autistic children were taught specific class members from the general classes of common objects, geometrical forms, and colors. It was an essential step to allow the subjects to learn and relearn all of the possible discriminations in order for them to perform the tasks required to perfection.

Harlows (1965) learning to learn phenomenon indicated that the more experience the subjects had to the learning situation, the less variability there was in errorless responding. This, in part, explained the errorless responding demonstrated by the two subjects in Program I.

Program II was designed to teach the subjects to select three geometrical shapes from a maximum of five available before him, and to place these three shapes in appropriateness of shapes selected and the order they were to be placed on the form board were cued by the

model presented at the beginning of each trial. Models consisted of three toy dolls, man, woman, and boy, seated on a small plastic chair of comparable size to the human dolls. The five geometrical shapes employed were a heart, circle, square, triangle, and a diamond.

The subjects could ultimately select the appropriate geometrical forms from among five forms in the selection population and arrange them in the proper sequence corresponding to whatever model was presented, man-on-chair, woman-on-chair, boy-on-chair. Program II was designed to teach the subjects to select three geometrical shapes from a maximum of five available before him, and to place these three shapes in the appropriate order on the form board.

The data from the first group of discriminations using the three symbols, heart, triangle, diamond, indicated that both subjects were to learn to produce a simple syntactic relationship by placing and arranging three symbols corresponding to man-on-chair on the form board in the presence of the model.

Subject I required fifteen trials to criterion on only one permutation, triangle-heart-diamond, otherwise completing the remainder of those permutations, the three geometrical forms heart-triangle-diamond, without errors. In contrast, subject II demonstrated a progressive decline

in the number of trials to reach the criterion measure. Fifteen trials were required for the first permutation, thirteen trials for the second and third permutations. Eventually, both subjects demonstrated errorless performances when those six permutations were alternated.

Training on the next two syntactical units, circle-triangle-diamond, then square-triangle, diamond, each unit haveing six permutations, evidenced errorless performance for subject II. Subject I had difficulty with the alternation presentation of the six permutations for circle-triangle-diamond; requiring fifteen trials to reach the criterion measure.

In the next phase, additional forms were added to the display presented to the subjects. The subjects were required to select three correct forms from among four geometrical forms, heart-circle-triangle-diamond and circle-square-triangle-diamond. This included the training of twenty-four permutations.

The results in Figure 12 demonstrated errorless acquisition throughout the twenty-four permutations for both subjects. Data in this figure supported the notion that correct performance was a function of the order in which permutations were presented and reinforced.

In the final phase of Program II, the subjects were required to select the three geometrical forms to be placed

on the form board from among all five forms. The possible orders that the five forms could assume were shown mathematically to be sixty.

However, it was not considered necessary to train the subjects on each of the sixty orders. Only five orders were chosen. Training to criterion proceeded immediately for both subjects, as demonstrated in Figure 12. Each of these five orders was then randomly presented. Both subjects demonstrated an errorless performance.

At the termination of Program II, both subjects were competent to choose the appropriate three geometrical forms from among the five forms in the selection population and arrange them in the proper sequence corresponding to whatever model was presented.

In Program II, the subjects were taught to discriminate between different symbols, a semantic function defined by Carrier (1972). They also were taught to discriminate between different sequential arrangements of symbols, a syntactic function described by Carrier (1972). Therefore, one concluded that both subjects had fulfilled two basic language functions, the semantic function and the syntactic function, by selecting and arranging the various sequences of geometrical forms in the presence of a model.

Program III was designed to teach the subjects to select and arrange three colors mounted on identical

cardboard backings, from a population of five colors placed before him. The appropriateness of his response was judged in terms of the constituencies of an arrangement of geometrical shapes presented as a model.

Colors employed were red, orange, blue, pink, and lavendar. The subjects were to sequentially select the colors and to arrange them in the proper order from the model presented by the experimenter. The model included one of the three syntactical units learned in Program II in response to the toy models, i.e., man-on-chair, woman-on-chair, and boy-on-chair. It was recalled that the corresponding geometrical sequences relevant to the toy models were heart-triangle-diamond, circle-triangle-diamond, and square-triangle-diamond.

Ultimately, the subjects could competently select the appropriate three color sequence from a population of five colors, arranging them in the proper order corresponding to one of the three model geometrical units, heart-triangle-diamond, circle-triangle-diamond, and square-triangle-diamond.

Program III was designed to teach the subjects to select and arrange three colors from a population of five colors placed on the table in response to the corresponding geometrical forms presented. The order of presentation of discriminations was identical to that of Program II.

The data, Figure 13, for the initial trials of Program III using the three colors orange-blue-pink, indicated that the subjects were to learn to produce a syntactical relationship by placing and arranging the three colors corresponding to the geometrical forms heart-triangle-diamond.

Both subjects required fifteen trials to criterion for the first two permutations, i.e., orange-blue-pink, blue-pink-orange, thereafter demonstrating a successive decline in the number of trials required for the criterion measure. Subject one required thirteen trials to criterion for the order blue-orange-pink, and twelve trials for the order orange-pink-blue before an errorless performance was demonstrated. Subject two required fifteen trials to criterion for the order blue-pink-orange, thirteen trials for the order blue-orange-pink, and eleven trials for the order orange-pink-blue before an errorless performance was recorded. Both subjects met the criterion measure of ten trials on the random presentation of those six permutations before a new syntactical unit was presented, red-blue-pink and lavendar-blue-pink.

Training on the next two syntactical color units, each consisting of six permutations, demonstrated an essentially errorless performance for subject one. Subject one encountered no difficulty in selecting and arranging the three colors corresponding to the geometrical

units circle-triangle-diamond or square-triangle-diamond as indicated in Figure 13.

Subject two required twelve trials to criterion for the first two permutations red-blue-pink and blue-pink-red, of the syntactical unit red-blue-pink, before an errorless performance was achieved. However, subject two completed the alternation of the six permutations for the sequence red-blue-pink without error.

Subsequent color permutations corresponding to the geometrical sequence square-triangle-diamond were encountered without error. Subject two demonstrated an errorless performance when the six permutations for the color sequence lavendar-blue-pink were alternated.

In the next phase, additional colors were added to the display presented to the subjects. They were required to select three correct colors from four colors presented, i.e., orange-red-blue-pink, and eventually the colors red-lavendar-blue-pink. This increased the number of possible orders from six to twenty-four.

The data recorded in Figures 13 and 14 demonstrated errorless acquisition throughout all the permutations for both subjects. The permutations were presented in a systematic fashion to insure results that would demonstrate errorless performances.

In the final phase of Program III, the subjects were required to select the three colors to be placed on the

form board from among five colors. The possible orders that five colors could assume were shown mathematrically to be sixty. However, it was not considered necessary to train the subjects on each of the sixty orders. Only five orders were chosen. Training to criterion proceeded immediately for subject two with the exception of one order, blue-pink-red-lavendar-orange, which required fifteen trials to criterion. This variation was accounted for in terms of extraneous competing behavior that was occurring during the sessions.

Subject one encountered some difficulty with the first two orders presented, requiring fifteen trials for both order, lavendar-orange-red-blue-pink and orange-red-blue-pink-lavendar, before an errorless performance was recorded.

Both subjects achieved an errorless performance when those five orders were alternated. They demonstrated a level of competence in choosing the appropriate three colors from among five colors in the selection population, arranging them in the proper sequence corresponding to whatever geometrical model was presented.

Program III taught the subjects to discriminate among different colors, a semantic function; to discriminate among different environmental events; and to discriminate among different sequential arrangements of colors, a

syntactic function. Carrier (1972) suggested that to learn language a child had only to acquire those three discriminations to demonstrate language behavior.

Normal children who can demonstrate vocal verbal behavior somehow could learn that complex response topography regardless of the presentation of discriminations. Non-vocal children, therefore, required a simplified response mode and an orderly presentation of discriminations in order to learn language. They could, however, be taught a response mode that would reduce language to its simple components, semantics, syntax, and the relationships between the two.

Further investigation was indicated in the area of discrimination training for a non-vocal, non-speech response mode. Added information would have increased the proficiency of language programs already in existence, and by and large, have influenced the rate of progress in language training programs for autistic children with impaired language development.

A P P E N D I X

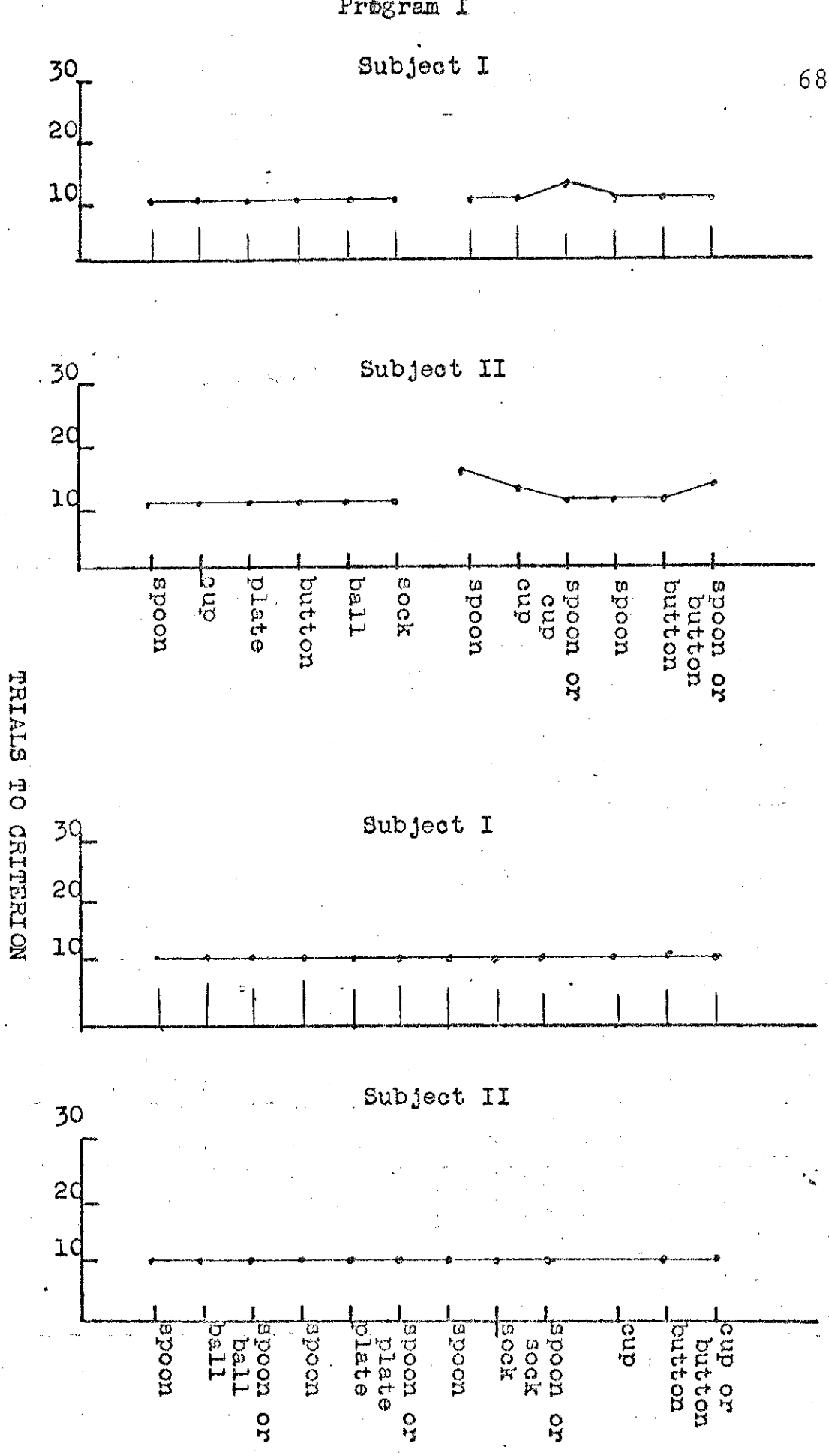

Figure 1--Acquisition of two-term relations in order of presentation.

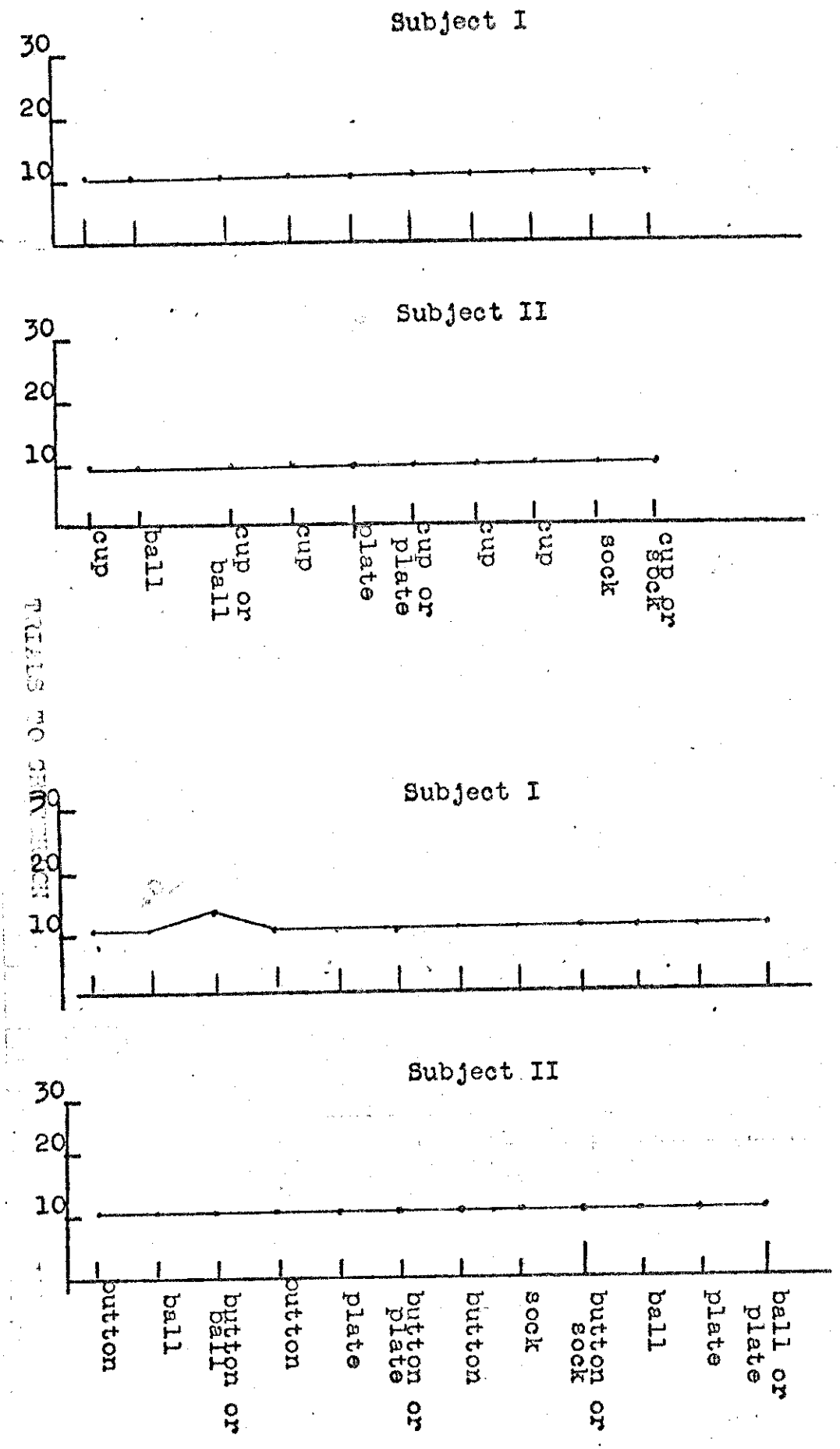

Figure 2--Acquisition of two-term relations in order of presentation.

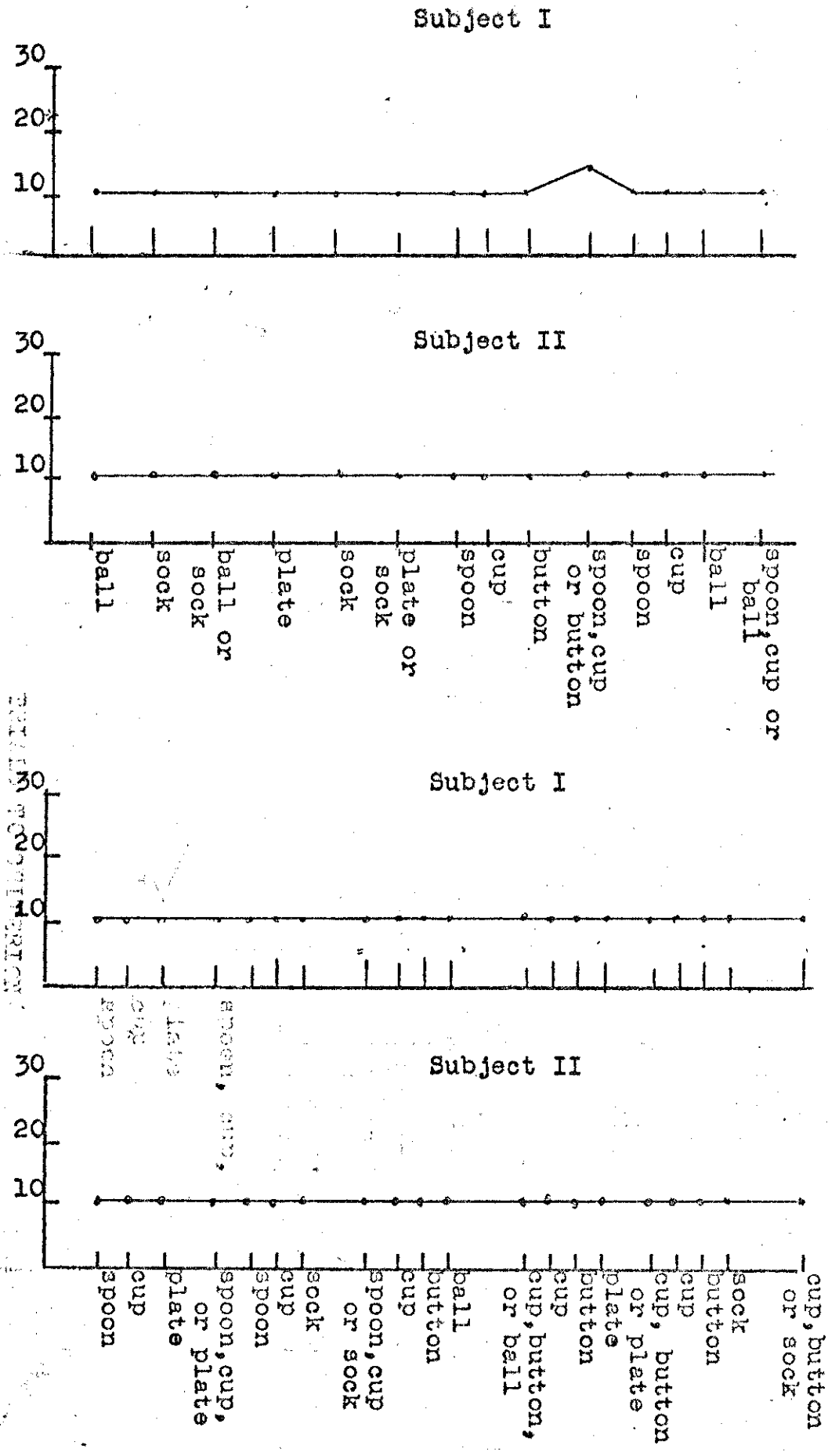

Figure 3--Acquisition of three-term relations in order of presentation.

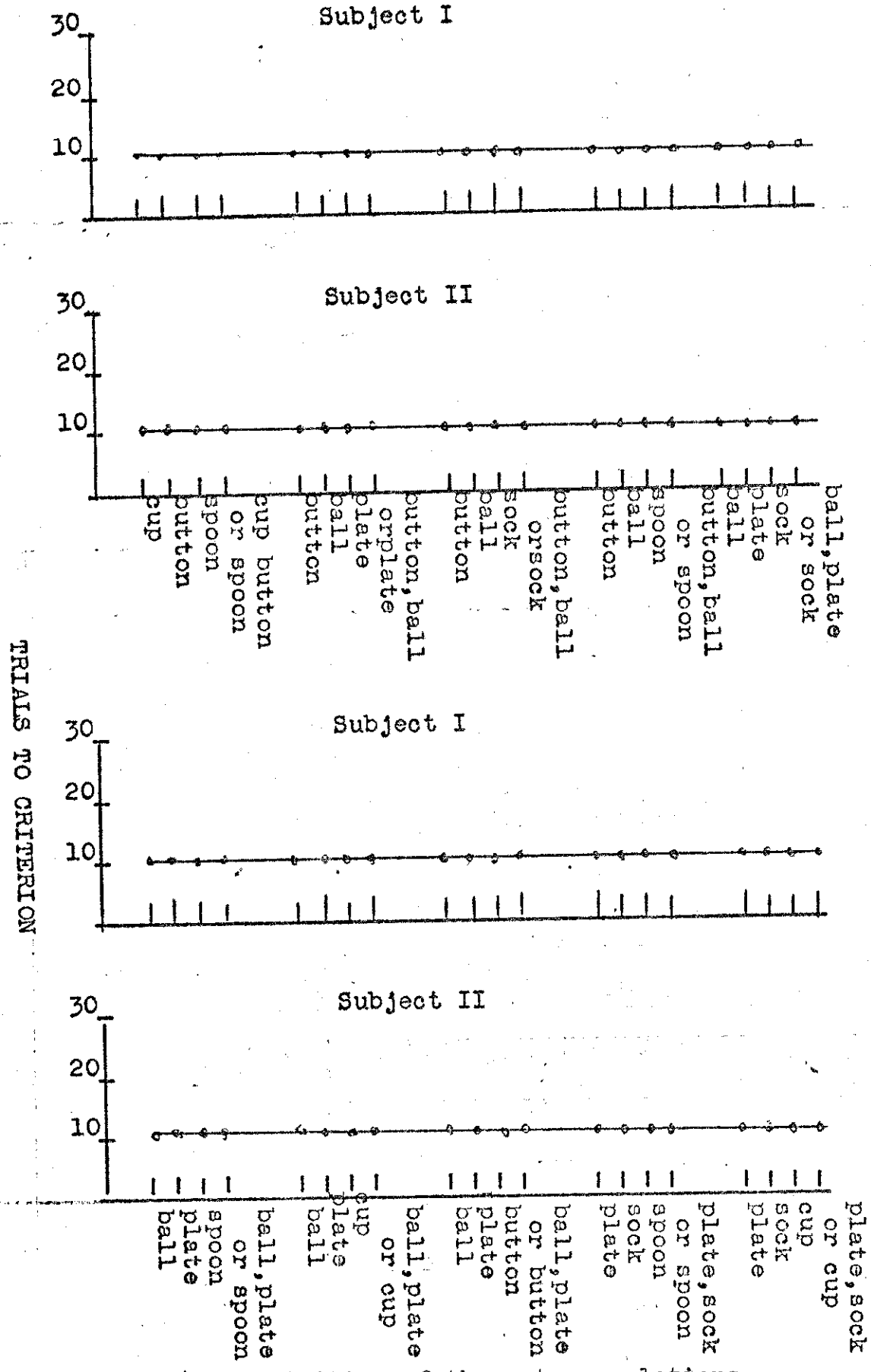

Figure 4--Acquisition of three-term relations.

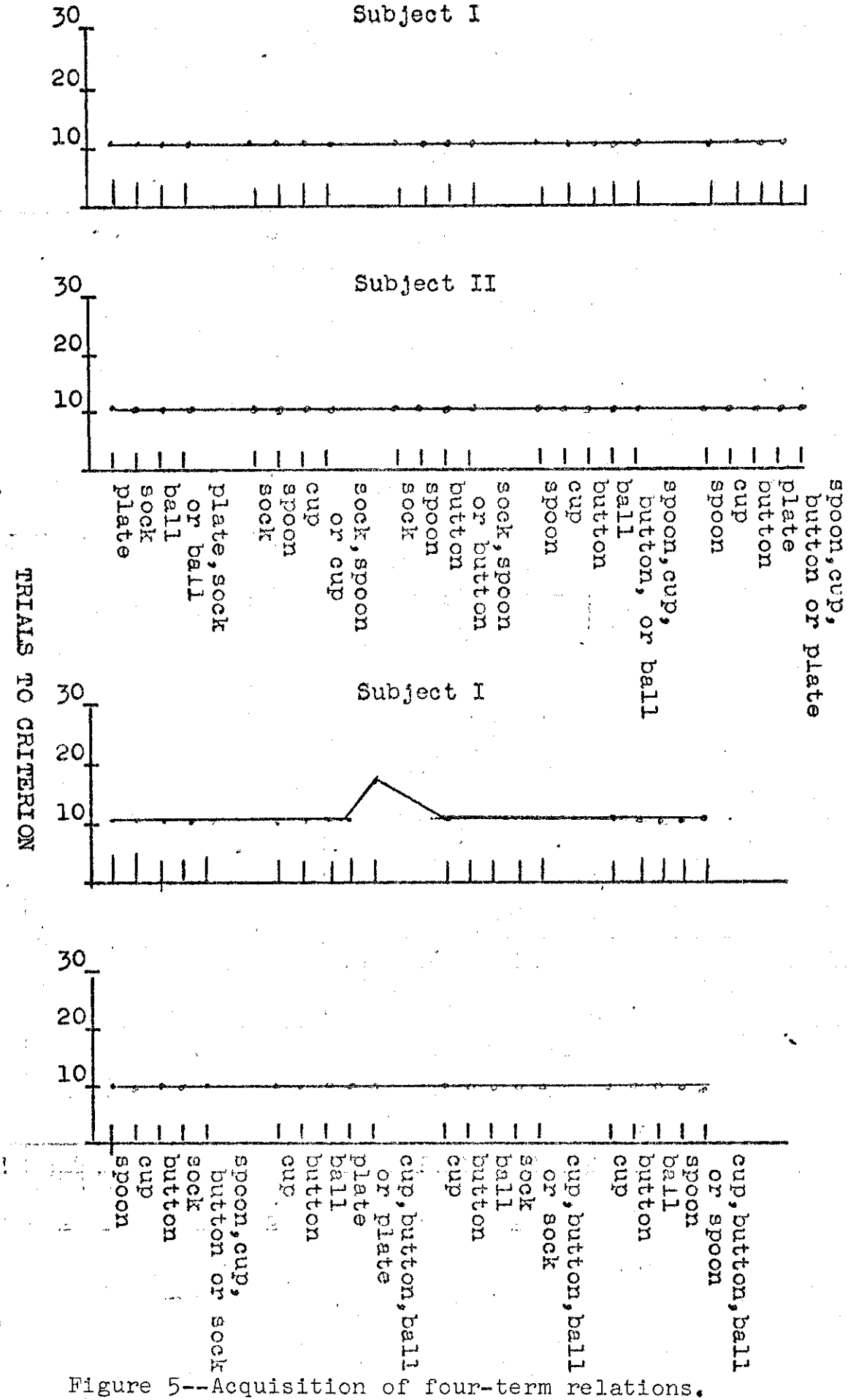

Figure 5--Acquisition of four-term relations.

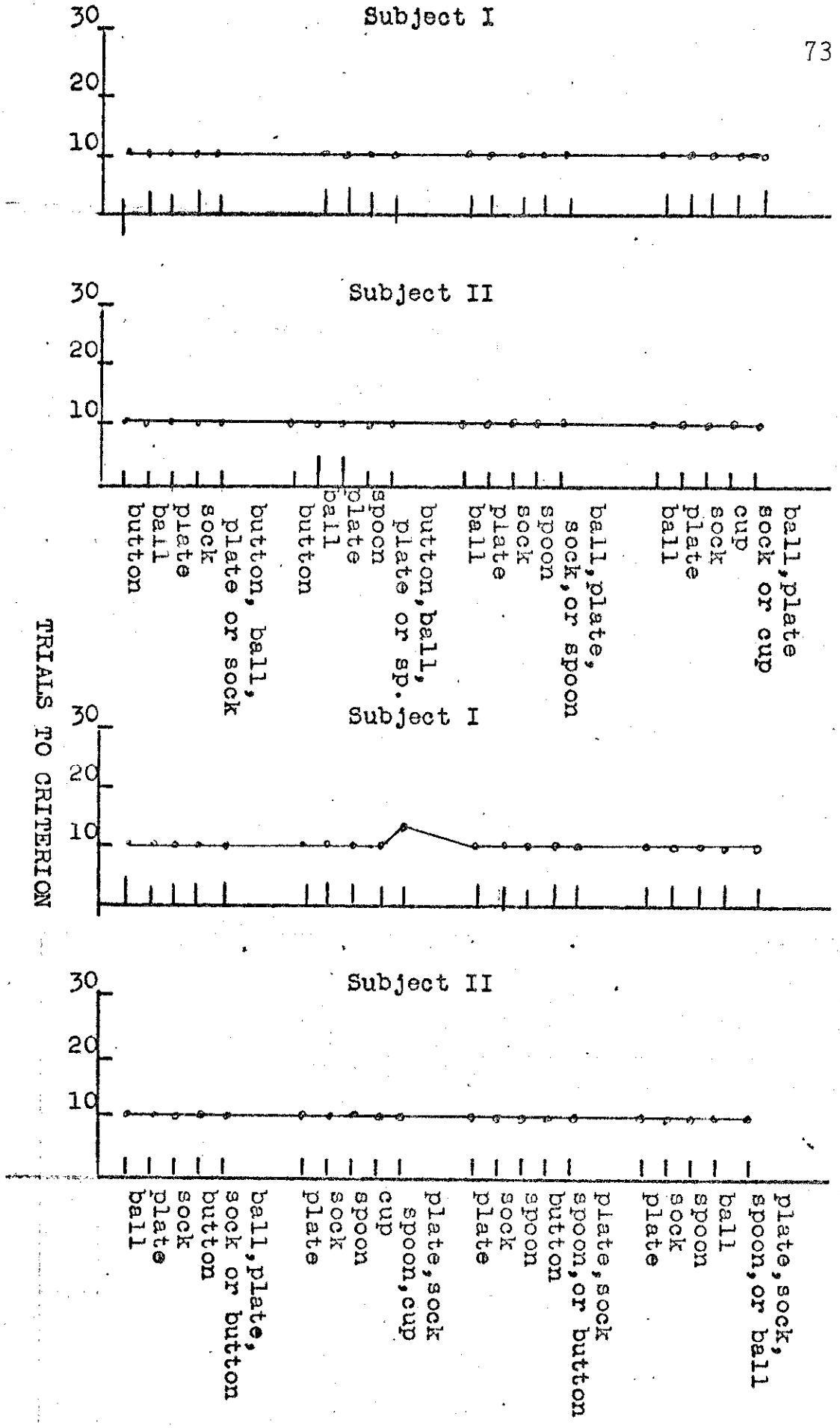

Figure 6--Acquisition of four-term relations.

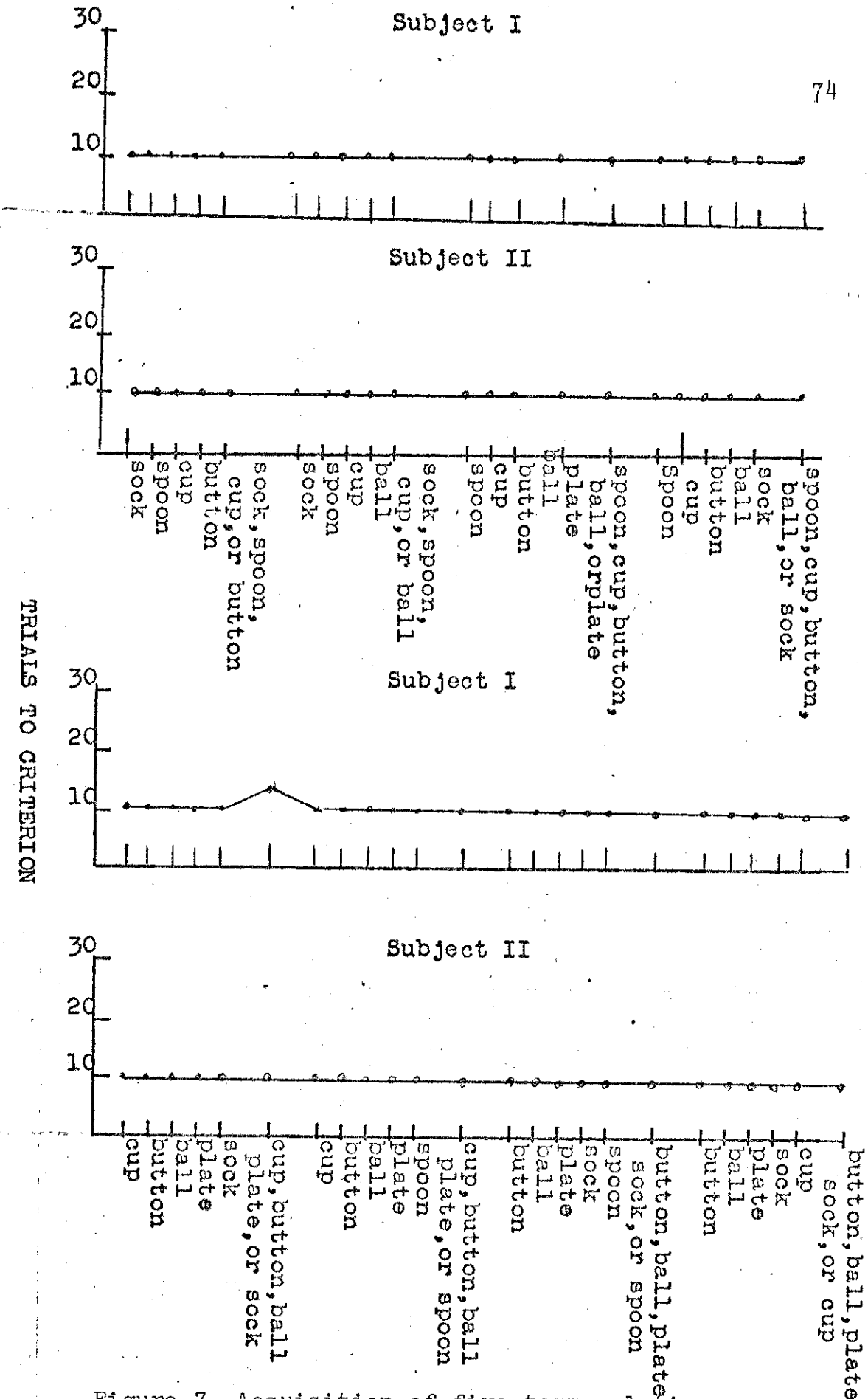

Figure 7--Acquisition of five-term relations.

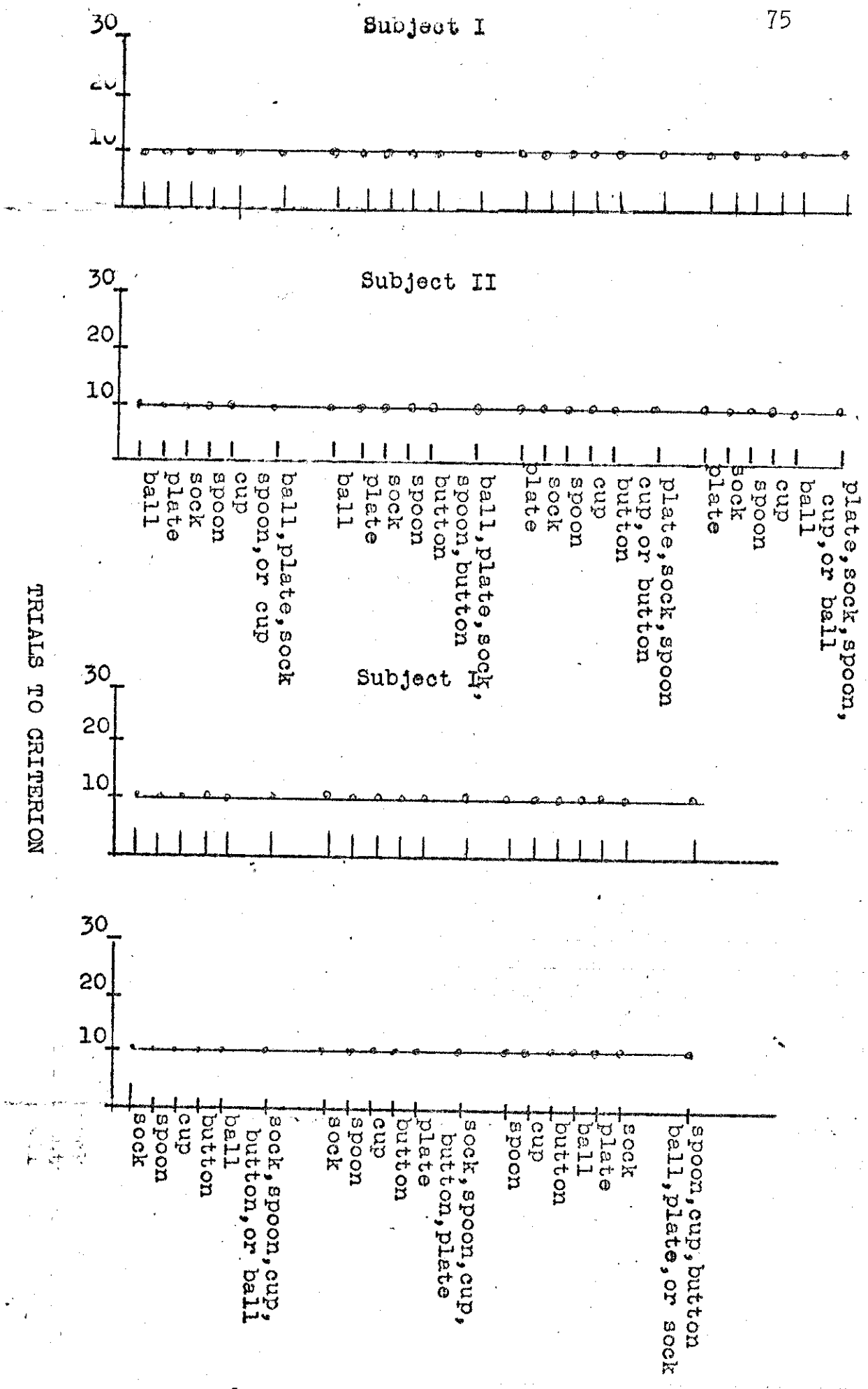

Figure 8--Acquisition of six-term relations.

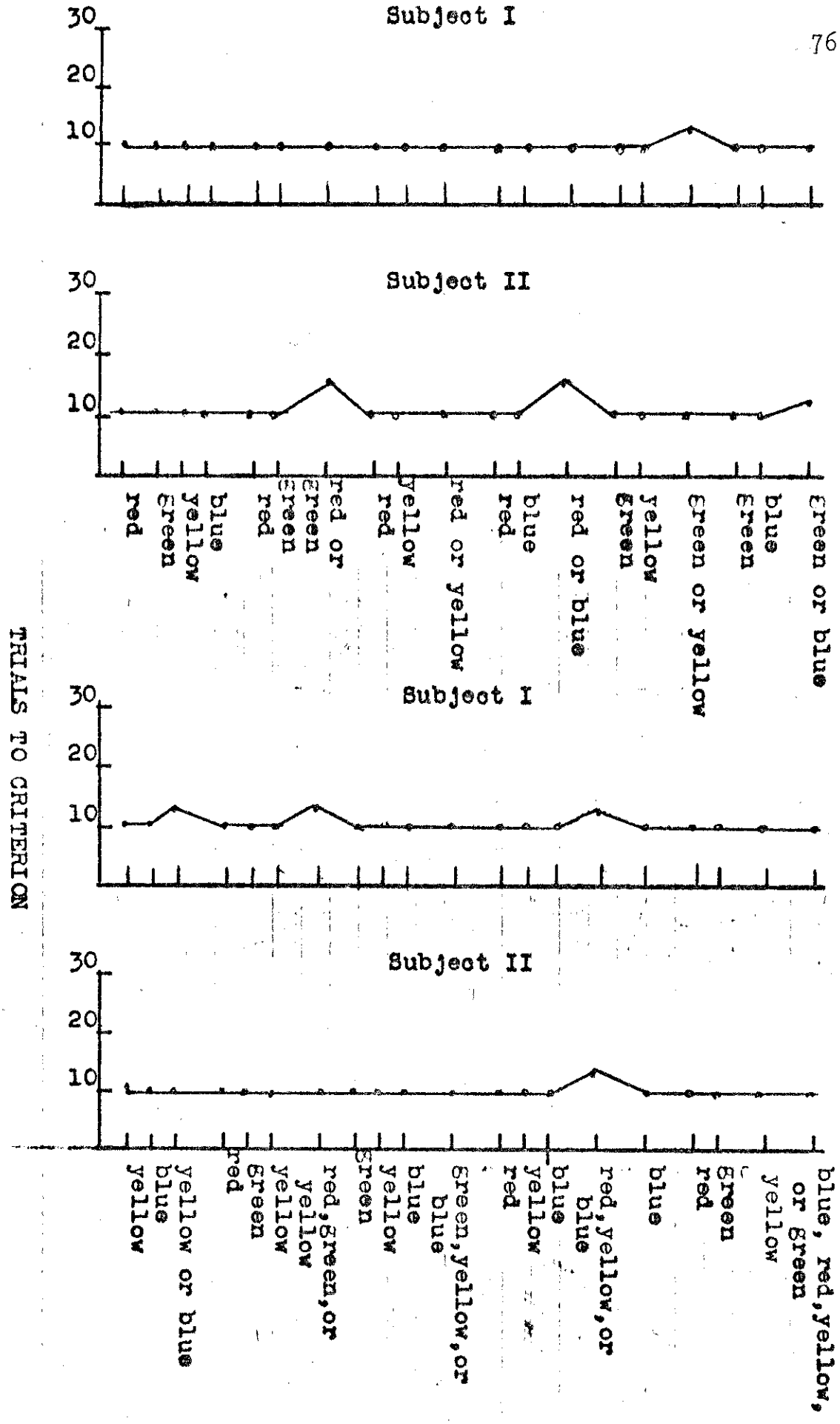

Figure 9--Acquisition of two, three, and four-term color relations.

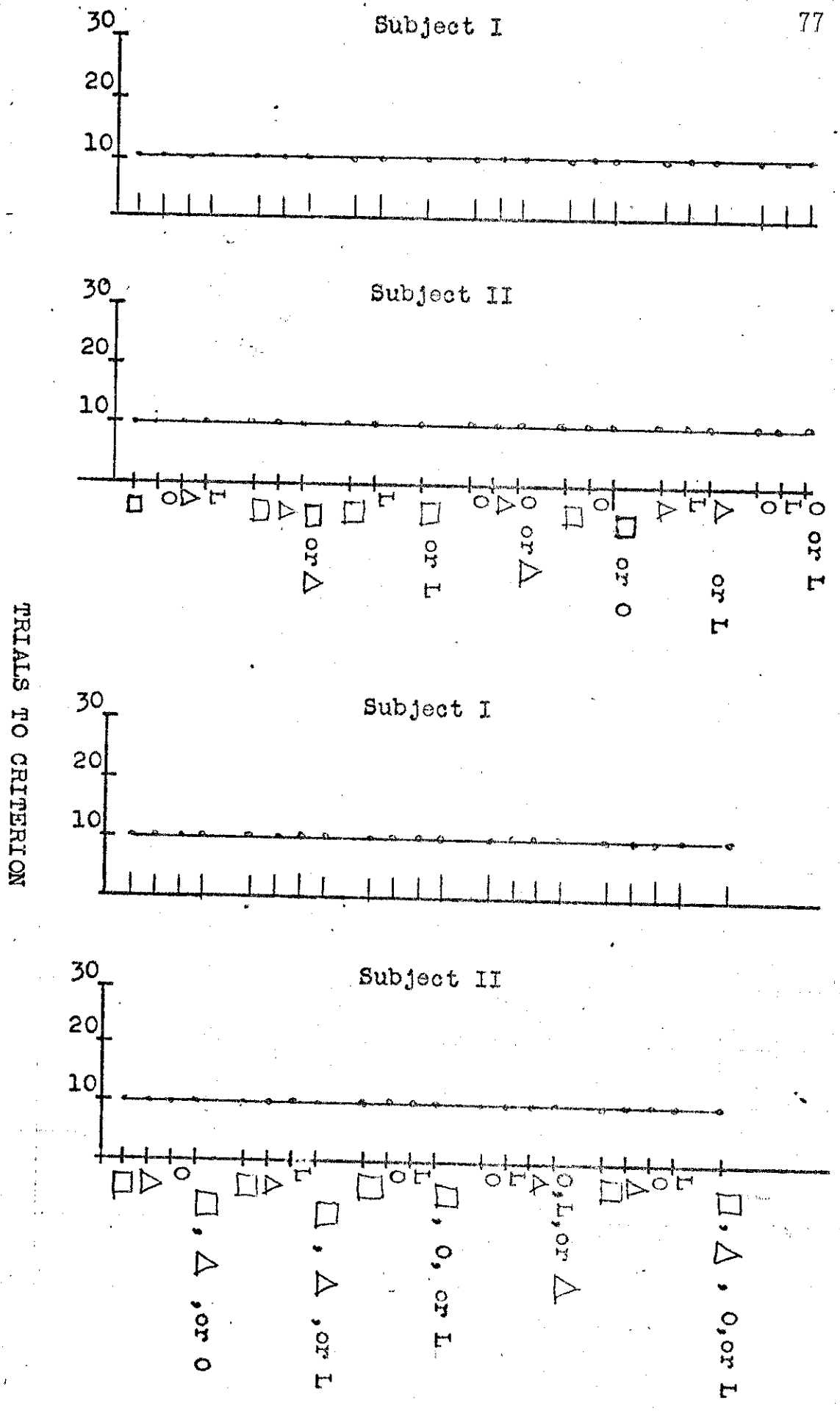

Figure 10--Acquisition of shape discriminations.

Program II

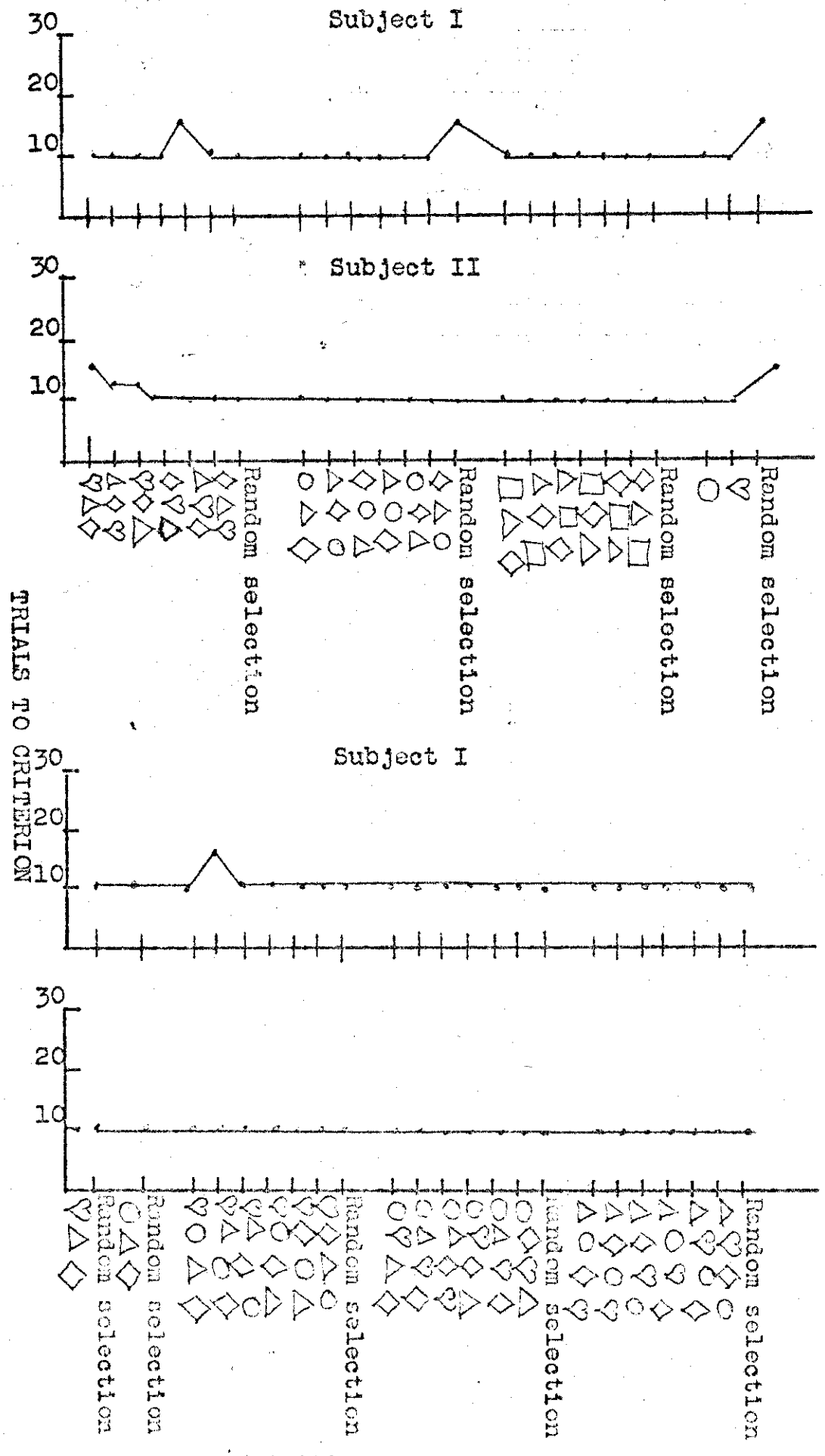

Figure 11--Syntax acquisition.

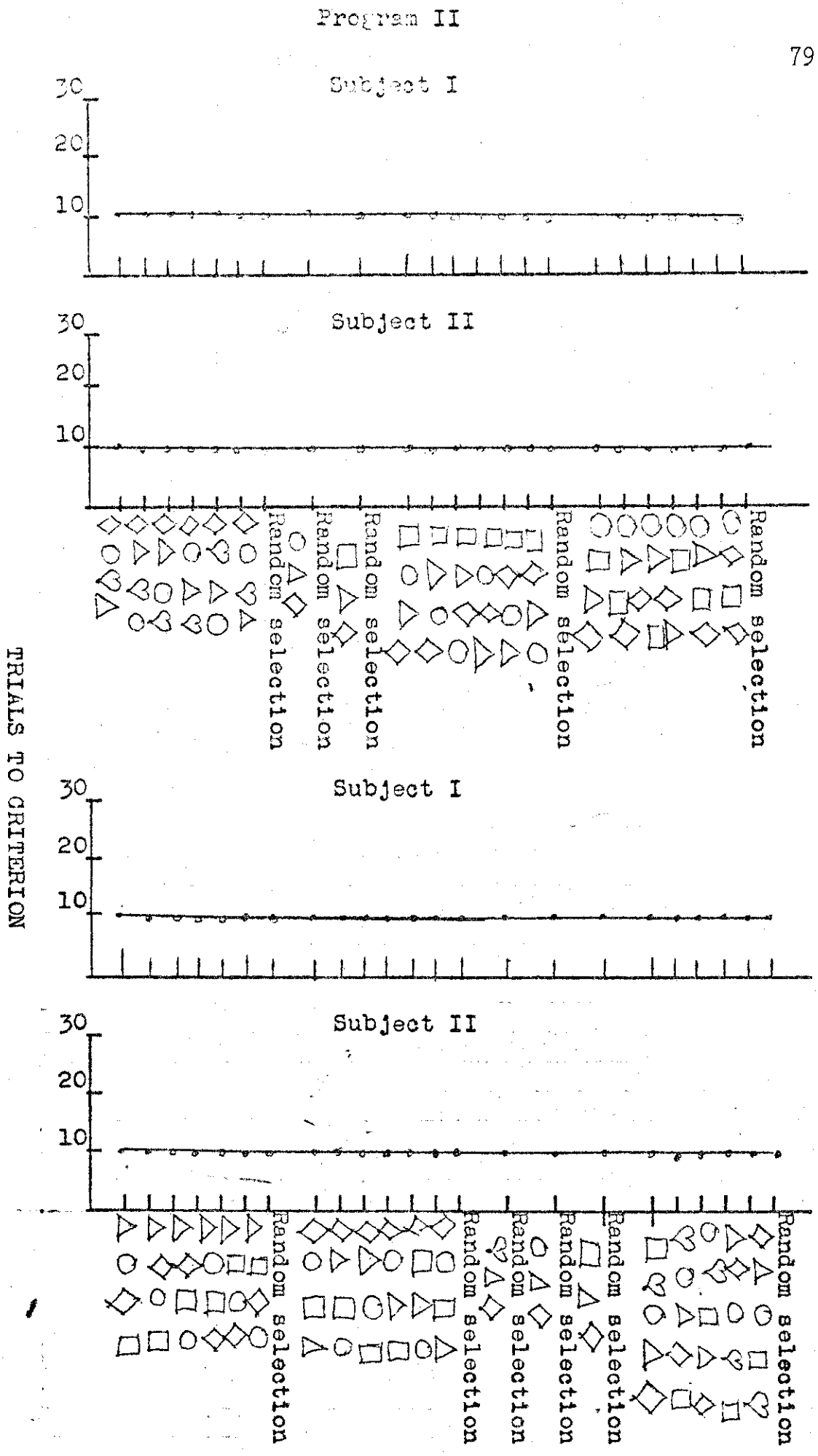

Figure 12--Syntax acquisitions.

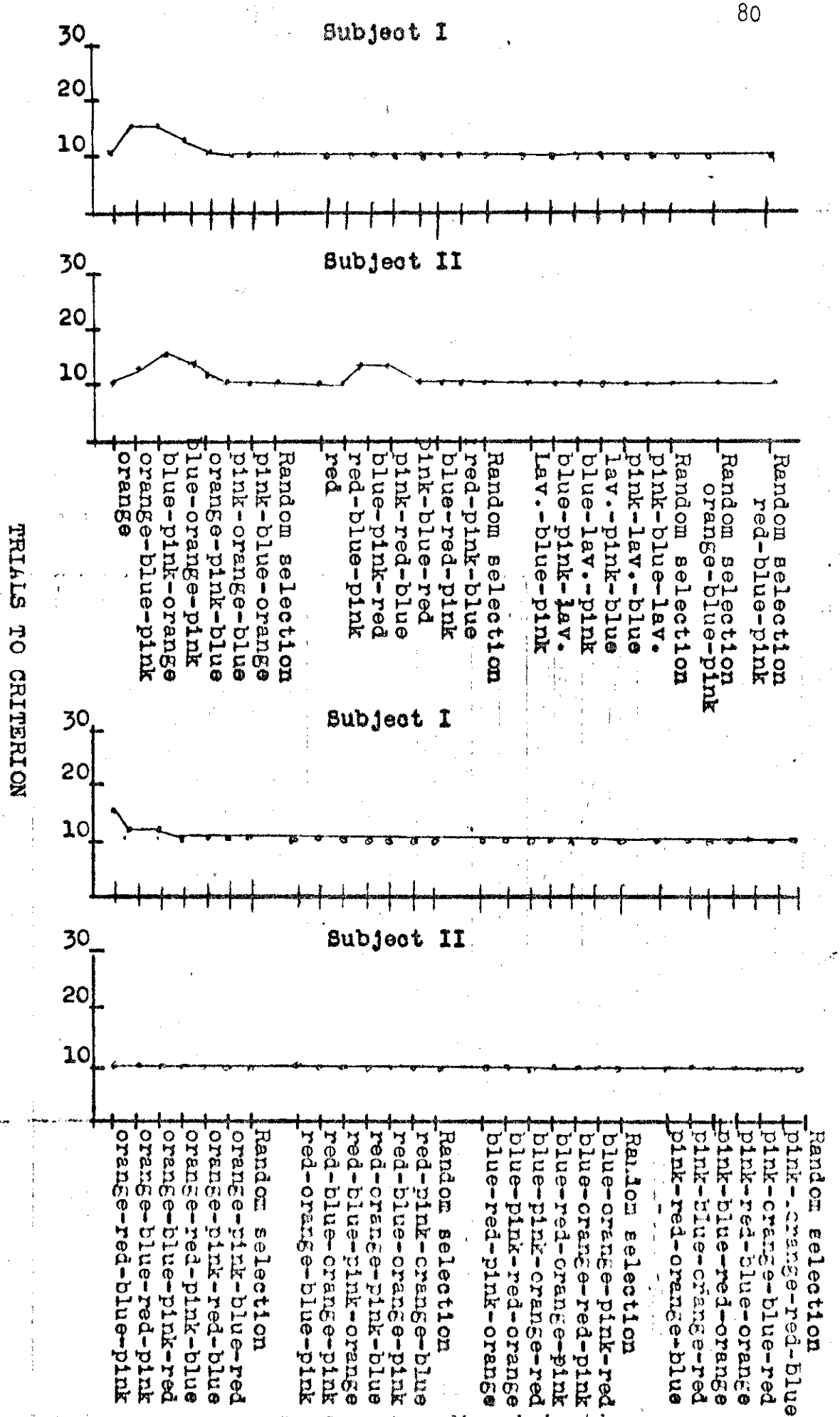

Figure 13--Acquisition of syntax discriminations.

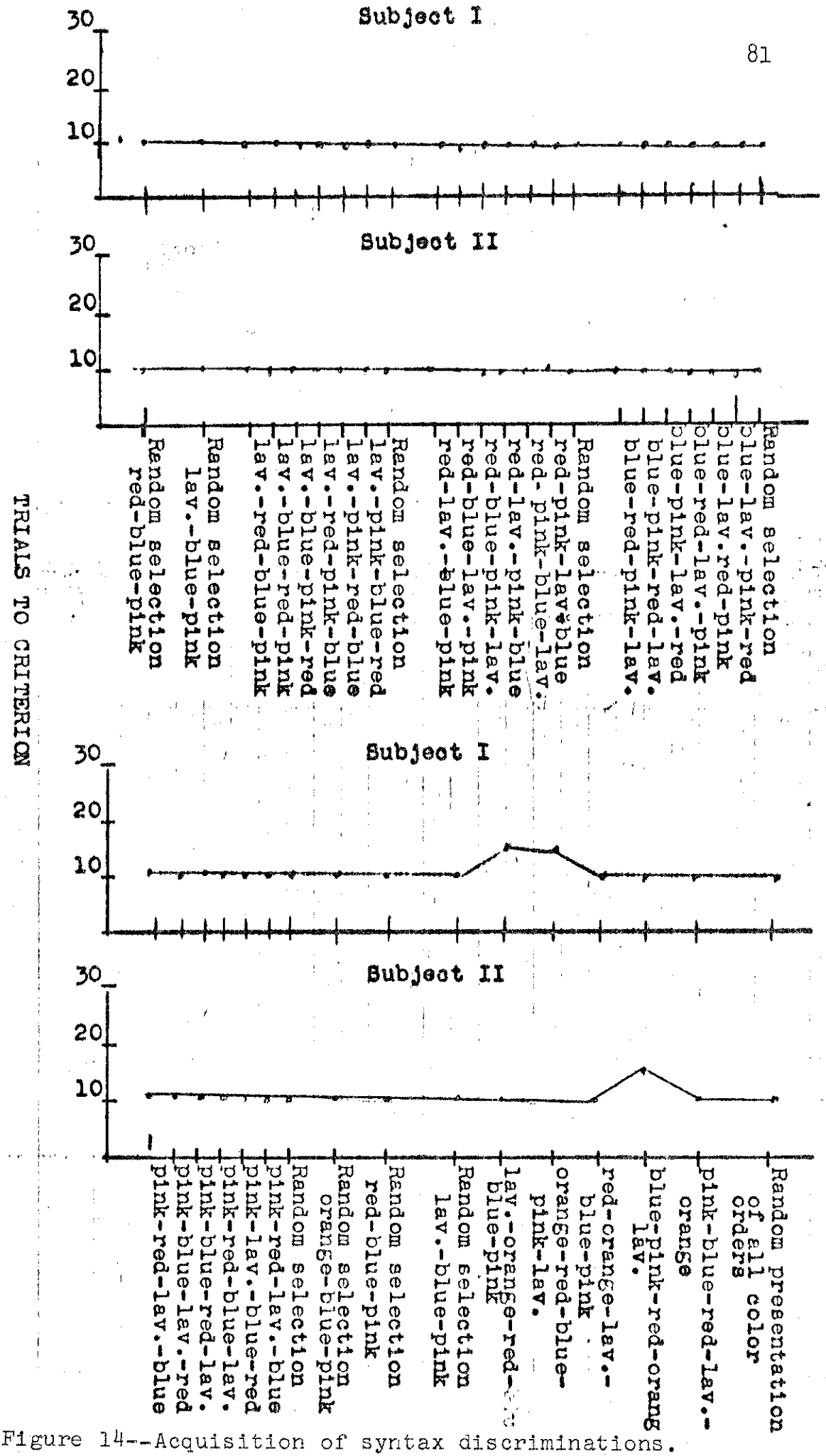

Figure 14--Acquisition of syntax discriminations.

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