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Physiological Bases of Children's Preferences for Picture Sequences

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PHYSIOLOGICAL BASES OF CHILDREN'S PREFERENCES FOR PICTURE SEQUENCES

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BY

ELIZABETH A. HIPSKIND

THESIS

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CHAPTER I

Introduction

The eye is the most active of all human sense organs. The eyes are in constant motion as they scan and inspect details of a visual world. Such movements of the eye are outside conscious control and can, therefore, provide insight into the processing of visual information by the brain. A person can determine what he looks at but not how he looks at it. It has been said that the "hard focus" of the eye sees only one one-thousandth of the entire visual field (Thomas, 1968). How then does the eye discern in considerable detail a complex and swiftly changing scene as that often seen in motion pictures? This task is accomplished by the rapid movements the eye is capable of making as the fovea receives images first from one part of a scene and then another. It has been shown that the movements of the eye play an important role in visual perception.

Noton and Stark (1971) studied eye movements of adults as they viewed stationary objects. They found that every person had a characteristic way of looking at an object that was familiar to him. Angles and other informative details were the features selected by the brain for remembering and recognizing and object. One of their main conclusions was that the internal

representation or visual memory of an object was a "piecemeal affair," an assemblage of features or more strictly of memory traces of features. During recognition the internal representation was matched serially with the object, feature by feature. In other words, visual perception of an object was greatly dependent upon the movements the eyes had made in recognizing the object.

Thomas (1968) in an overview of eye movement literature found that it was evident from other studies that when an observer's interest was aroused his eyes moved more often. Gould and Schaffer (1965) also showed a relationship between eye movements and visual perception. In their study of eye movements of adults viewing a numeric display they found that the spatial distribution of eye fixations or the movements of the eye served as an indicant of cognitive behavior.

The most common eye movement is the saccade, or the rapid jump the eye makes as it moves from one fixation of a visual scene to another. It is widely accepted that nearly all visual perception occurs during the fixations of the eyes. More perception time could take the form of more fixations or longer fixations, or both (Fleming, 1969). It is assumed the person will look at the parts of the picture that hold for him the most information. Analysis of the order of fixations suggests a format for the interconnection of features (Noton and Stark, 1971). Therefore, for the purposes of this investigation into the physiological bases of visual literacy, the frequency of fixations,

the duration of fixations, and the study of saccades as they connect fixations to form a pattern will be considered.

Number of Fixations

A wealth of information exists in the literature concerning the role eye fixations play when a person views the visual world. Common among these findings is the direct relationship between the frequency of fixations and visual perception (Noton and Stark, 1971; Guba and Wolf, 1964; Gould and Schaffer, 1965; and Gould and Peeples, 1970). When an observer's interest is aroused by what he sees his eyes move more often (Thomas, 1968). This factor of movement may, therefore, account for more fixations. This factor according to Guba and Wold (1964) means that an "impression adequate for perception occurs only during the fixational pause when the image is nearly at rest upon the retina." In their study, Gould and Schaffer (1965) found that nearly all visual perception occurs during the fixations of the eyes while little or no information is obtained between fixations. They suggest that cognitive behavior is indicated by an increase in the number of fixations and duration of fixations is relatively constant. In other words, the more information a subject drew from the display the more fixations he made. Gould and Peeples (1970) showed that a refixation of a particular pattern (increase in the number of fixations) indicated a need to obtain more information about it.

Duration of Fixations

It seems obvious that the duration of fixations is related

in some way to the amount of information the observer receives. Gould and Peeples (1970) suggest that it is a reflection of the time needed to process the information. The duration of fixation varies from as little as .065 second to as much as 2.7 seconds (Buswell, 1935). In an early study, Buswell (1935) found one type of eye movement pattern in response to looking at static pictures and designs consisted of a series of fixations usually longer in duration concentrated over a smaller portion of the field evidencing detailed examination of those sections. This compared to a pattern in which the eye moved in a series of short pauses over a main portion of the picture in which little information was obtained.

Studies involving subjects viewing Rorschach inkblots resulted in some interesting hypotheses about the duration of fixation (Thomas, 1968). The duration, he found, depends upon the "character" of the scene. Researchers believe that the lengthening of fixation time may be associated with the diminishing intake of information and reflects a process in which the viewer is adding or generating meaning, rather than merely accepting it. This supports the view taken by Yarbus (1961). He concluded that it was natural for the sequence and the duration of fixation on a particular element of a scene to be determined by the process of thinking which results in interpretation. A discussion of the sequencing of fixations appears to be appropriate at this point.

Eye Movements: Scanning Patterns

Some studies have shown that vision is greatly impaired during the rapid eye movements. Richards (1969) stated that vision was impaired during rapid eye movements and it is believed that neural factors were involved in the visual suppression associated with saccadic eye movements. Thomas (1968) found that saccades take only a few milliseconds and that vision was greatly reduced. She went on to state that the speed of the saccade was dependent upon its length and direction and that these varied from individual to individual. Scott and Bickford (1967) differentiated between eye movements and showed there was a resistence to blur during scanning eye movements. In their study of forty-three first grade students, Guba and Wolf (1964) thought eye movements served in maintaining or changing the fixation without disturbing a person's continued coherence of the visual world.

Scanning patterns have been studied in the past. Thomas (1968) found that when someone is looking at pictures or groups of pictures the scanning patterns seem to be individualistic (a given individual on a given picture). They were consistent but there was no preferred sequence in which areas were inspected. Schissler (1969) found a tendency to look at the center simply because it was the center but that other patterns were varying among subjects. In their study on visual search and discrimination of meaningless symbol and object pattern, Gould and Peeples (1970) found that subjects scanned the patterns in

different ways. Each subject generally used his same scan pattern throughout the experiment.

Noton and Stark (1971) came to some interesting conclusions in the study of scanning patterns as people looked at objects. They found that every person had a characteristic way of looking at an object that was familiar to him. During normal viewing of stationary objects, the eyes alternated between fixations and saccades. Each saccade led to a new fixation on a different point in the visual field. Typically there were two or three saccades per second. The movements were so fast that they occupied only about ten per cent of the total viewing time. Just as the location of fixation indicated that probable nature of the features, so analysis of the order of the fixations suggested a pattern for the connection of features. Lines representing saccades formed broad bands from point to point and did not crisscross the picture at random. The overall record indicated a series of cycles; in each cycle the eyes visited the main features of the picture, following regular pathways. That fact that each subject had different scanning patterns for different pictures suggests that scanning patterns are not the result of some fixed habit of eye movements. Their results reveal the order of feature processing. They concluded that the features of an object are "that part of it tnat yield the most information" and that the saccades connect the features in preferred order, forming a feature ring and resulting in a scan path" (Noton and Stark, 1971, p. 39).

One general conclusion seems apparent: scanning patterns are highly individualistic behaviors. As Yarbus (1961, p. 52) put it: "People that think differently see differently." Some general information concerning search patterns has been ascertained. Fry and Enoch (1957) found that the pattern divided into two phases. Phase I consisted of an orientation or basic search in which the eyes move in a very individualistic manner and Phase II was a specific search which was dependent upon the observer's finding some clues in the orientation phase which he can utilize. This is consistent with Buswell's earlier findings. Fleming (1969) found eye movements to vary with such variables as type of targets, the number of elements, the similarity of target to non-target and the size of the display. It appears safe to assume that no one characteristic pattern exists.

Studies with Children

Vurpillot (1968) in studying various age groups of children as they viewed "same" and "different" stimulus found that children under six never considered the whole stimulus but rather made judgements on small portions of information. Mackworth and Bruner (1968) found that they visually trace out contours which suggests that children concentrate visually on detail more than previously had been thought. Schissler (1969) when comparing subjective ratings to fixations found that informativeness (meaning obtained from a feature) had a definite relationship to location of eye fixations on the picture. Eight-year-old children were used in this study. Noton and Stark (1964)

believed that a person will look at the parts of the picture which he regards as the features and hold for him the most information. As previously stated it is believed the study of the location of fixations will indicate the nature of the features so analysis of the order of fixations will provide a means to study the interconnection of features a person makes. As scanning patterns have been shown to be individualistic and particularly so with children, individual observation on each child's scanning patterns by tracing from fixation to fixation by means of saccades will be necessary in the hope of discerning the features to which a child attends.

The direct relationship of eye movements to visual perception was discussed. The number of fixations and the duration of fixations have been shown to indicate cognitive behavior. The more fixations a child makes and an increase in the duration of these fixations are measures of the child's obtaining more information from a visual display. The points of fixation determine the features to which a child attends while the interconnection of these fixation points gives the format for the interconnection of features. Saccades, or the rapid movements the eye makes, serve to connect fixation points into a scanning pattern. For the purposes of this investigation the number of fixations, the duration of fixations and the study of saccades as they form a scanning pattern will be the measures to determine to which features a child attends and which features the child puts together while putting pictures together to tell a story.

Statement of Purpose

The purpose of this investigation is to describe the physiological measurements of a child's eye movements in relation to attending to visual stimuli as he views adult-generated and child-generated picture sequences. A second purpose of this investigation is to analyze the relationship of these physiological measurements to psychologically scaled values determined for the picture sequences.

In view of the stated purposes, the following questions were considered:

1. What is the number of eye fixations a child makes when viewing an adult-generated picture sequence?

2. What is the number of eye fixations a child makes when viewing a child-generated picture sequences?

3. What is the amount of time spent by a child viewing an adult-generated picture sequence?

4. What is the amount of time spent by a child viewing a child-generated picture sequence?

5. To what features does a child attend when viewing a picture sequence?

6. What is the relationship of physiological measurements to the psychologically scaled values attached to the picture sequences?

CHAPTER II

Review of Literature

This investigation is proposed as a logical sequel to past and present research at Eastern Illinois University in the area of visual literacy. The following topics will be discussed in this review: the learning process, cue attention, the effects these have on the educational process, visual literacy research and its results to date, and finally some methodological considerations.

The concept of visual literacy has been defined by the Conference on Visual Literacy:

> Visual literacy refers to a group of vision-competencies a human being can develop by seeing and at the same time having and integrating other sensory experiences. The development of these competencies is fundamental to normal human learning. When developed, they enable a visually literate person to discriminate and interpret the visual actions, objects and/or symbols, natural or man-made, that he encounters in his environment. Through the appreciative use of these competencies, he is able to communicate and enjoy the master-works of visual communication (First Conference on Visual Literacy, 1969).

The importance of the development of these vision competencies and their integration to other sensory modalities cannot be overemphasized. A child, very early in life, appears to develop what has been called a visual vocabulary (Debes, 1969). His frequent observations of a sequence of visual events allow

him to learn and interpret its meaning or in effect, "read it."

The Learning Process

Beadle (1970) defined learning as "a process which brings about lasting change in an individual's behavior as a result of contact with the environment." She found that the eyes respond to the light waves that strike them but that the person does not see - in the sense of comprehension - until his mind has evaluated and reached an opinion as to the meaning of the raw data provided by the eyes. Only when this has been done can he know where he stands in relation to the environment as it is at any given moment, and act accordingly. In her studies, Beadle found that infants as early as fifteen days were able to discriminate between visual patterns. Weisstein (1970) found that there is activity in the visual cortex throughout the process of recognition and learning.

As the visual vocabulary builds, it becomes filled with images which carry significance for the child because of its involvement with the rest of the kinesthetic response system. This is why the baby stops crying even before he has been fed when he sees his mother fixing his dinner. As the verbal vocabulary begins to develop, it is based on prior experiences of which visual events are obviously dominating. Thus development at this early stage of the verbal vocabulary is greatly dependent upon the visual vocabulary. It might be argued that strengthening the visual vocabulary would necessarily increase the chances of

a properly developed verbal vocabulary. Debes (1969) contends that children can be trained to use their existing "passive visual vocabulary" more creatively and thereby enhance their verbal vocabulary.

Cue Attention

A child receive practice in making visual choices when he chooses to attend or not to attend to the visual phenomenon about him. He soon learns to draw conclusions from scenes chosen in an order and variety that satisfies his own needs. Debes (1968) aptly describes it as a satisfaction of the "hunting reaction" and the need for proprioceptive involvement. The need to do one's own cognitive ordering in response to one's own idea of unfulfilled information is satisfied.

Nature abounds with examples of animals learning to choose one thing rather than another and to use the features of stimuli as guides to appropriate action. The young learn to distinguish on the basis of a number of cues (Riley, 1968). Riley's (1968) work in conditioning resulted in the denial or modification of the law of effect. This law states that all stimuli striking the receptors at the time a response is made will be associated with the response if this event is followed by a satisfying state of affairs. Riley found that only the stimuli attended to will be associated.

Kagan (1970) explained learning as the process of acquiring schema which are representations of experiences. The first schema represents invariant stimuli patterns that are a part of

a larger context characterized by a high rate of change. The establishment of a schema is dependent upon the selectivity of the infant's attention. The earliest determinant of duration of orientation to a visual event is probably inherent in the structure of the central nervous system. Events that possessed "a high rate of change in their physical characteristics, that are moderately discrepant from established schemata and that activated hypotheses in the service of assimilation" had the greatest powers to recruit and maintain attention in the young child. The duration of attention come under the influence of the relation between a class of events and the infant's schema for that class.

Heineman (1968) found that an organism attends to a dimension of stimuli if variations in the value of stimuli produce variations of behavior; otherwise he is said not to attend. Riley (1968) defined attention as an event in the brain that "determines which aspect of a stimulus complex controls the subject's behavior." Moreover, he states that a variety of factors such as novelty, usefulness, previous experience, and others make it possible for one aspect of the stimulus to control behavior one moment and another aspect the next. As will be seen in past visual literacy research, training in sequencing pictures changed the subject's behavior in relation to the same visual stimuli.

Weisstein (1970) found that different populations of neurons respond differentially to features of a stimulus. Discrimination

occurs on both the conscious and unconscious levels (Shevrin, 1968). The ability to separate a scene into its component parts is vital for any pattern recognition. According to Weisstein (1970) this separation proceeds in two steps. In the first step, the features are abstracted from the visual array. In the second step, the relationships between these features are tested with reference to internal models which specify how things are supposed to look in space.

The acquisition of a conditioned response proceeds faster as the child matures. With increased age, the child becomes more selectively attentive and better able to differentiate the relevant signal from the background noise (Kagan, 1970). Lovejoy (1968) found that all learning was selective. If learning is selective, what influences the child's preference for one cue or feature of a stimulus over another? Gliner, et al (1969) found three factors which influenced the preferences of kindergarten children:

> ...discriminability of stimulus differences has an effect on observed preferences. Discriminability and preference are not equivalent, however; preference is not a simple function of discriminability...usefulness of informativeness value of available stimulus dimensions...the salience or attention-getting value of some rather than other available stimulus dimensions.

Lovejoy (1968) found that adding an irrelevant cue slowed discrimination learning.

Effect of the Educational Process

The present flow of visual images in the educational process is, however, one determined by an adult in response to an

adult's perceptions and feelings. The child's cognitive development is based, not on his choices but on an adult's. His concept of idea organization and presentation becomes an adult's conception. This is supported by LaPolt (1968) who drew the following conclusions:

> Evidence clearly indicates that the ability of visualization and sequential memory in youngsters from ages five to eight is not adequately developed to enable them to successfully order more than a few written or oral expressions. Evidence gathered during Regional Summer School also clearly indicates that when the youngsters planned to take a series of photographs, the number of ideas they could successfully order doubled, or tripled (LaPolt, 1968).

Even early educators realized the problem at hand. John Dewey made the following statement concerning the direction of education:

> Purely external direction is impossible...while the customs and rules of adults furnish stimuli as well as evoke the activities of the young, the young, after all, participate in the direction which their actions finally take. In the strict sense nothing can be forced upon them or into them (Bundy, 1970).

Good learning will happen only when the process is effectively connected to what the learner wants and is able to understand.

It becomes apparent then that what constitutes visual literacy for the child may be quite different from that for the adult. Important implications for education are made. When visual sequencing activities are taught it is assumed that a teacher can select relevant stimulus material for visual literacy training and that teachers can relevantly eveluate visual stimuli generated by their students (Miner, 1971). If these assumptions are invalid, the teaching-learning process becomes less effective.

In the Beadle study (1970), third grade children were asked to describe pictures in their own school books. In each picture there were twenty to twenty-six constituent items whose perception was important to an understanding of the pictured scene. The children identified fewer than one-third of the items. Specific knowledge of the perceptual impact of various picture sequences on children could greatly enhance the development of picture sequencing abilities in children. Little systematic research in the area has been attempted probably due in part to the fact that such entities as "visual literacy" or "picture sequencing" are difficult to quantify or measure (Miner, 1971).

Visual Literacy Research

It is in light of the above discussion that past and present visual literacy research is being conducted at the university.

Strandberg and Griffith (1969) attempted to determine if visual behavior could facilitate verbal behavior and thus measured the relationship between visual experience and the verbal behavior associated with the visual experience. The subjects were four- and five-year-old children in a kindergarten program. The subjects took pictures on three occasions: once of toys, once at home, and then again at home. The experimental group received training in visual sequencing activities before taking pictures at home the second time. After each task the pictures were developed and the child was asked to talk about his pictures. Language samples were taken and measured by the Length-Complexity Index, the Spontaneity Index, Total Number of Words, and the Number of

Different Words. The authors came to the following conclusions:

1. The subjects' language responses were significantly longer and grammatically more complex when they were talking about pictures they made at home compared to pictures they made of specified individual objects.

2. Training in picture sequencing significantly increased the length and complexity of the subjects' language responses.

3. Subjects' language behavior was significantly more spontaneous when they described pictures made at home compared to pictures made of toys.

4. The LCI seemed to be the most sensitive measure to changes in language behavior brought about by training in visual literacy or the content of the pictures a child had made.

5. Children do sequence pictures without special training.

In following up this study Strandberg, Griffith and Miner (1970) conducted a study to determine if adults could reliably scale both child-generated and adult-generated picture sequences and to assess the relationship between verbal syntax and visual syntax. Two sets of twenty picture sequences were obtained. The first set of pictures was selected by the investigators from commercially prepared (adult-generated) sequences. The second set was generated by preschool children. These forty sequences were presented to three four-year-old children and language samples were taken. These were measured by the LCI to determine the length and complexity of the evoked language. Two panels of adult judges then psychologically scaled the sequences on a seven point equal appearing interval scale, one rating the adult

sequences and the other rating the child-generated sequences. The results were as follows:

1. Adults can scale adult-generated sequences with a high degree of reliability.

2. Adults can scale child-generated sequences but with less reliability.

3. A weak, positive relationship (r = 0.05) exists between LCI scores and mean scale values for the adult-generated picture sequences.

4. A weak relationship (r = -0.10) exists between LCI scores and mean scale values for child-generated picture sequences.

5. LCI scores were significantly higher for child-generated sequences than for adult-generated sequences.

This study suggests that adults agree with other adults as to the meaningfulness of picture sequences but not with children. The results found here also confirmed those obtained by the earlier Strandberg and Griffith study. That is, children's responses are significantly longer and grammatically more complex when talking about self-generated pictures.

Kingery (1972) assessed the feasibility of psychological scaling methodology with preschool children. The purpose of her study was to determine whether children could reliably scale both adult- and child-generated picture sequences for visual syntax and to assess the relationship between verbal syntax and visual syntax. The psychological scaling method used was paired comparisons in which the child merely indicated which of two

picture sequences told the better stody. The following summarizes her findings:

1. A panel of thirty observers were able to scale ten child-generated sequences in their forty-five pairings with a reliability of 0.95. Thus children agree highly with other children as to the constitution of a visually literate sequence.

2. Children can scale adult-generated visual sequences but with less reliability than when scaling child-generated sequences. That is, a much larger number of children would be required to receive a rank ordering as stable as that already existing for the child-generated sequences. Children, then, though they agree among themselves as to the constitution of a viaully literate child sequence are not agreeing nearly as highly with adults.

3. Children do not speak in significantly longer and structurally more complex utterances when describing sequences generated by other children than when describing adult-generated sequences.

4. A weak correlation existed between visual and verbal syntax in children's scalings of adult-generated sequences.

5. No relationship beyond chance existed between visual syntax and verbal syntax in children's scalings of child-generated sequences.

6. A correlation of only 0.05 existed between the rank orderings of the initial experimental group and a cross validation group of black children when they rank ordered the adult-generated sequences.

7. With a sample size of only six a correlation of 0.70 existed between the initial experimental group and a cross validation group of black children when scaling child-generated sequences. That is to say, then, that children, children from very different backgrounds, agree highly among themselves as to what constitutes childness but do not agree among themselves as to what constitutes adultness.

This being true the next logical step then appears to be to find out what it is about the child-generated sequences that make children agree highly among themselves as to their preference and what it is about adult-generated sequences that make children not so highly agreeable as to their preference. In other words, to what features of a picture sequence does a child attend which carry meaningful and non-meaningful information?

Summary of Results

Pertinent findings of research done at this university in the area of visual literacy to the present are:

1. Children use longer and more complex language when talking about self-generated sequences than when talking about adult-generated sequences.

2. Training in sequencing pictures significantly increases the length and complexity of subjects' language responses.

3. Adults agree highly with other adults as to what constitutes a visually literate picture sequence but not with children.

4. Children agree highly with other children as to what

constitutes a visually literate picture sequence but do not agree as highly with adults.

That more research has to be done is obvious because of the growing implications for new educational materials which these results generate. Many questions are yet unanswered. The features of the picture sequences to which a child attends need to be known so that more relevant visual sequencing tasks can be utilized. Physiological measures need to be made to determine what the centers of interest are, what features are more concentrated upon and what the visual scanning strategies are for meaningful and non-meaningful picture sequences. Perhaps the most partinent question to be answered is the feasibility of physiological measures on children's perceptual abilities.

This investigation is judged to be significant for the following reasons: 1) the assumption that teachers can select relevant materials for visual literacy training and that teachers can evaluate visual stimuli generated by their students may be invalid; 2) physiological measures of the stimuli to which a child attends when viewing a sequence of pictures are lacking; 3) the relationship between physiological and psychological measures should be assessed; and 4) research about the visual scanning strategies employed by children when viewing meaningful and non-meaningful picture sequences is lacking.

Difficulties arise when measuring the eye movements of a young child as he views sequences of pictures. One must first identify the measures to be taken and then discern a plausible

method to obtain these measures.

Methodological Considerations

The problem now becomes one of proper instrumentation to use with children. A wide variety of techniques have been utilized by researchers to study the movement of the eyes. For measurements so refined as those mentioned above, four techniques are commonly used. They are direct photography, electrographic techniques, contact lens techniques and corneal reflection techniques. The method of direct photography appears self explanatory, i.e., the eye is photographed directly by means of still or moving cameras and eye movements are directly observed. A discussion of the remaining techniques follows.

The Electro-oculograph uses the electrostatic field that exists between the front and back of the eye as its basis for measurements. The method as used by Wolf and Wendt (1967) consists of placing electrodes about both eyes. The eyes were then measured independently of each other and a summation of the two eye movements was recorded graphically. The feasibility of this method with small children seems slight as the attachments of electrodes directly to the child will undoubtedly introduce variables which could not be controlled for. The most serious disadvantage of the electro-oculographic technique is its inaccuracy which may be due to muscle or skin potentials entering the data (Knemeyer and Wolf, 1969).

The contact lens technique consists of the subject being individually fitted with contact lens to which is attached some

method or recording eye movements. A small lamp has been used which shines various amounts of light through a focusing surface and then onto a photomultiplier. The electrical output is then used to measure the movement of the eyes. The most obvious disadvantage of this technique for use with children is fitting a child with contact lens.

The corneal reflection technique is a technique commonly used in educational research. The basis of measurement here is the reflection of light off the cornea of the eye. This beam of light is then photographed and the eye movement recorded. Equipment such as the Reading Eye falls into this category. Hess (1965) used this method to measure pupil dilation. The position of the eye was also recorded onto the stimulus. A fixed head, however, was necessary to ensure accuracy. Mackworth and Mackworth (1958) developed a head-mounted camera to eliminate the necessity of stabilizing head movements. This method also had its limitations (Thomas, 1968). The equipment weight severl pounds, vision in one eye is reduced by a mirror which picks up its movement and the helmet may move.

Since it has been shown that eye movements of greater than 18^{0} (Von Tscherack and Seyenegy, 1952) usually involve head movements and that a head movement of 0.75 mm can cause loss of calibration between the subject's eye movements and the indicated position, a method of recording eye movements which took these factors into account had to be considered. The method to be employed for purposes of this study will be described in detail below.

The implications for new educational materials generated by past research at Eastern Illinois University was discussed. Studies by Strandberg, Griffith and Miner (1970) and Kingery (1972) have pointed to the need to know to what features a child attends when viewing picture sequences. The direct relationship of eye movements to visual perception was discussed in this review. The number of fixations and the duration of fixations have been shown to indicate cognitive behavior. The number of fixations and the duration of these are indices of how much information a child is gaining from a visual display. The points of fixation determine the features to which a child attends while the interconnection of these fixation points gives the format for the interconnection of features. Saccades, or the rapid movements the eyes make, serve to connect fixation points into a scanning pattern. For the purpose of this investigation, the number of fixations, the duration of fixations and the study of saccades as they form a scanning pattern will be the measures to determine to which features a child attends and which features the child puts together while putting pictures together to tell a story.

The four main techniques for obtaining measures of eye movements and the problems of each were discussed. The main concern here was to obtain the most accurate measure possible while imposing minimum restrictions on the child. Freedom of movement for the child was felt to be needed to help reduce some of the variables imposed by any testing situation. Of the four major techniques, direct photograph appeared to be the

logical choice to assess physiological measurements of eye movements of very young children. The method used to obtain these measures will be discussed in Chapter III.

CHAPTER III

Procedures

I. Selection of Subjects

Four subjects participated in this investigation. They were between the ages of four years, six months and four years eleven months. They were chosen from the available population in the Charleston-Mattoon area. The following table lists the birthdate, age at the time of testing and hometown of each subject.

TABLE I

LIST OF SUBJECTS USED IN STUDY

Subject	Birthdate	Age	Home
M.B.	9-17-67	4- 7	Charleston
A.L.	6- 7-67	4-10	Mattoon
M.R.	6-11-67	4-11	Charleston
L.G.	11- 5-67	4- 6	Charleston

The justification for the use of a small n lies in the design of this study. The design of this study is descriptive; the behavioral phenomenon under study is attention to features. Sidman (1960) suggests that when studying a phenomenon rather than the phenomenon as it is related to the subjects it is better to use a small number of subjects who demonstrate the pheonmenon than a large number of subjects. It is not the intent of this investigation to generalize the results to large populations but

rather to study a phenomenon.

II. Examiners

Two examiners were present in the testing situation. One was a graduate assistant in the Department of Speech Pathology and Audiology at Eastern Illinois University. This examiner gave the verbal directives. The other examiner was a graduate assistant in the Department of Audio-Visual Instruction at Eastern Illinois University. This examiner ran the camera equipment and determined the correct lighting and optimum camera angles.

III. Stimuli

The stimuli consisted of eight of the twenty picture sequences used in the Kingery (1972) study. In her study twenty picture sequences, ten adult-generated and ten child-generated, were rank ordered according to children's preference by the psychological scaling methodology of paired comparisons. The ten adult-generated sequences had been randomly selected from thirty-five sequences which had been prepared in previous visual literacy projects conducted at Eastern Illinois University. The sequences consisted of three inch by three inch commercially prepared pictures from Kodak's Photo Discovery Sets. The ten child-generated sequences were randomly selected from 309 existing child-generated sequences. These also consisted of three inch by three inch pictures, ranged in length from two to six pictures, and had been prepared in previous visual literacy research projects at Eastern. The selected sequences for the present investigation were centered

and mounted on four by twenty-two inch pieces of white cardboard. The sequences used in this study were those which ranked the two highest and the two lowest in each of the child-generated and adult-generated categories when the rank orderings of all the sequences were considered together. Specifically sequence numbers 8 and 7 (high child-generated), 6 and 5 (low child-generated), 16 and 12 (high adult-generated), and 17 and 11 (low adult-generated) were used. A brief description of each sequence follows.

Sequence No. 7: This sequence ranked the highest of the child-generated sequences. Six pictures comprised this sequence. The first picture was of two girls playing on a porch. The second picture was of a girl standing on a step holding a doll. The third picture was of the same girl holding the same doll on the step. The fourth picture was of a different girl on the step holding the same doll. The fifth picture was of a girl holding a doll while sitting on a porch swing. The sixth picture was of a girl looking through the screen of the porch.

Sequence No. 8: This sequence ranked the second highest of the child-generated sequences. Six pictures comprised the sequence. The second picture was of a cat lying on a bed. The third picture was of a boy sitting in a chair. The fourth picture was of a dog sitting in a chair. The fifth picture was of a dog jumping up on a man. The sixth picture was of a tree in a field.

Sequence No. 5: This sequence ranked ninth of the child-generated sequences. Two pictures comprised this sequence. The

first picture was a close-up of a lady; only the distance between her shoulder and knee was visible. The second picture was a full view of the same lady at a distance.

Sequence No. 6: This sequence ranked the lowest of the child-generated sequences. Two pictures comprised the sequence. The first picture was of a boy working in a work room. The second picture was a closer shot of the same boy in the same room.

Sequence No. 16: This sequence ranked the highest of the adult-generated sequences. Five pictures comprised this sequence. The first picture was of a clock; it was seven o'clock. The second picture was of someone placing silverware on the breakfast table. The third picture was of two eggs frying in a skillet. The fourth picture was of someone putting toast into a toaster. The fifth picture was of someone holding a plate of buttered toast.

Sequence No. 12: This sequence ranked the second highest of the adult-generated sequence. Two pictures comprised this sequence. The first picture was of a dog sitting up begging. The second picture was of the dog eating out of a dish.

Sequence No. 17: This sequence ranked ninth of the adult-generated sequence. Two pictures comprised this sequence. The first picture was of a boy being reprimanded. The second picture was a close-up of the boy's eye with a tear running down his face.

Sequence No. 11: This sequence ranked the lowest of the adult-generated sequences. Three pictures comprised this sequence. The first picture was of a woman leaning up in bed as if she heard something. The second picture was of some broken dishes. The third picture was of the woman comforting her daughter.

IV. Equipment

A Bolex 155 Super 8 mm camera was used for all filming and was chosen due to its availability. This Bolex model is equipped with a Macrozoom 8.5-30 mm f/1.9 lens. The diaphragm apertures ranged from f/1.9- f/16. The camera was loaded with Super 8 Movie film in fifty feet cartridges with a cartridge duration of three minutes, twenty seconds at the speed of 18 frames per second. Exposure time is 1/47 second at 18 frames per second.

Two thirty by twenty-four inch mirrors were used to pick up and reflect away from the child the image of the child viewing the picture sequences. Both mirrors were framed and mounted in stands which allowed them to be tilted at any horizontal angle. One stand was smaller to allow its placement on a table. Vertical and horizontal lines, one inch apart, were drawn on this mirror.

A Wollensak tape recorder was used to tape all testing sessions.

Two Vernon 808 film editors were used to analyze the film. These editors have a four and a half by four and a half inch viewing screen which was judged by the investigator to be of adequate size to measure eye movements accurately. They also allowed a frame by frame analysis of the film to be made.

V. Methodology

Each child was brought into the testing room and seated at a small table. The testing room for all subjects was Room 205 of the Speech and Hearing Clinic at Eastern Illinois University.

Only one child and the two examiners were present in each testing session. In front of the child on the table was a thirty by twenty-four inch mirror in a stand which allowed it to be tilted at any horizontal angle to the subject. Vertical and horizontal lines, one inch apart, were drawn on this mirror. Above and behind the subject was another thrity by twenty-four inch mirror in a similar but larger stand. This mirror was tilted in such a manner as to pick up and reflect away from the child the image in the lower mirror. A four by twenty-four inch stimulus card was attached to the lower mirror in front of the subject by means of clasps and string which allowed the card to be raised and lowered on the mirror surface. On this card was centered a variable (two to six) number of pictures comprising a picture sequence. The stimulus card was positioned in such a way as to allow maximum view of the child's eyes as he looked at the picture sequences. The image of the child looking at the picture sequences was reflected into the upper mirror. A Bolex 155 Super 8 mm camera, out of the child's sight, photographed the image in the upper mirror.

To facilitate pinpointing the exact feature to which the child was attending, another set of film was taken. Small pictures of objects were placed at predetermined points on a four by twenty-two inch card. This card was placed directly over the previously described stimulus card. Such a card was made for each length of picture sequences used as the stimulus. Some of the sequences were comprised of the same number of pictures and, therefore, the same object card was used for those equal in length.

The child was instructed to focus on each object as it was named by the examiner. This was filmed in the same way mentioned above. The filming of the child focusing on the various objects directly preceded the filming of the picture sequence for which that object card was made.

The verbal directives given to each child were:

> You know pictures can sometimes go together to tell a story. In a story book, the pictures help to let us know what the story is about. I brought some pictures with me today, but my pictures don't have a story. I want you to look at the pictures and make up a story to go with all the pictures. First I'm going to show you some other pictures; I want you to look right at the picture and keep looking at it until I tell you to look at a different one.

Each child was questioned on his knowledge of the verbal directives and they were repeated and explained if necessary. Each child was instructed to remain seated in his chair. The child's movement was not restricted beyond this.

After being developed, the two sets of film were simultaneously compared in two Vernon 808 film editors. In one editor the film in which the examiner knew the precise point of fixation (the pictured objects) was compared to the film in which the points of fixation were unknown. A horizontal line drawn through the centers of the two pupils as they look straight ahead was used as a reference point. The distance above and below this line and to the left and right of the midpoint of this line that the center of the eye deviated gave the angle of the eye's line of sight. The vertical and horizontal lines drawn on the lower mirror were used to determine if eye movement had taken

place and were used as reference points for the angle of the eye's line of sight in relation to each picture of each picture sequence. Knowing the angle of the eye as it is fixating on a known point was used as a reference point in determining the point the eye was fixating at any given angle. A frame by fram analysis was made and the information was transferred to data sheets. The analysis was made by the same examiner on two separate occasions and percentages of agreement were calculated. The examiner agreed with herself 100 per cent on the frequency of fixation and agree with herself 96 per cent on the duration of fixation. All testing sessions were tape recorded.

Fixation is operationally defined as the time in which the eye is steadily directed to a position. This time must exceed .065 seconds.

1. Duration of fixation was measured by counting the number of frames in which the eyes were fixated to one point and multiply by .0625 seconds. 2. The number of fixations were measured by adding the number of times the eyes were fixated to one point for more than .065 seconds. 3. The scanning strategies or features to which a child is attending while putting pictures together to tell a story were determined by the fixation points. Scanning strategies were determined, specifically, by interconnecting the fixation points. The scanning patterns were drawn on plastic overlaying the picture sequences.

CHAPTER IV

Results and Discussion

Four subjects between the ages of four years, six months and four years, eleven months viewed four child-generated and four adult-generated picture sequences. These sequences ranked the two highest and the two lowest in each of two categories, child-generated and adult-generated, when psychologically scaled by the method of paired comparisons (Kingery, 1972). In accordance with these procedures six questions were posed at the onset of this investigation. This chapter reports and interprets the results of the obtained data. The design of this investigation is descriptive; therefore, data analysis concerning frequency and duration of fixation will be primarily through graphic display with subsequent interpretations of performance data.

I. Frequency of Fixation for Child-Generated Sequences

The following figures, numbers 1, 2, 3 and 4, illustrate the frequency of fixations for each subject as they viewed the child-generated picture sequences. The child-generated sequences were divided into two categories: High Child and Low Child. The High Child category consisted of picture sequences seven and eight which ranked one and two respectively in the Kingery (1972) study. They were ranked according to their scaled values when

psychologically scaled by the method of paired comparisons. The Low Child category consisted of picture sequence numbers six and five which ranked ninth and tenth respectively for child-generated sequences in the Kingery study. Table II below illustrates the sequence numbers from her study viewed by each subject.

TABLE II

CHILD-GENERATED SEQUENCES VIEWED BY EACH SUBJECT

Subject	High Child	Low Child
1	8	5
2	7	5
3	7	6
4	8	6

For the figures below the sequence number is entered in parentheses along the abscissa with its ranking from the Kingery study below it.

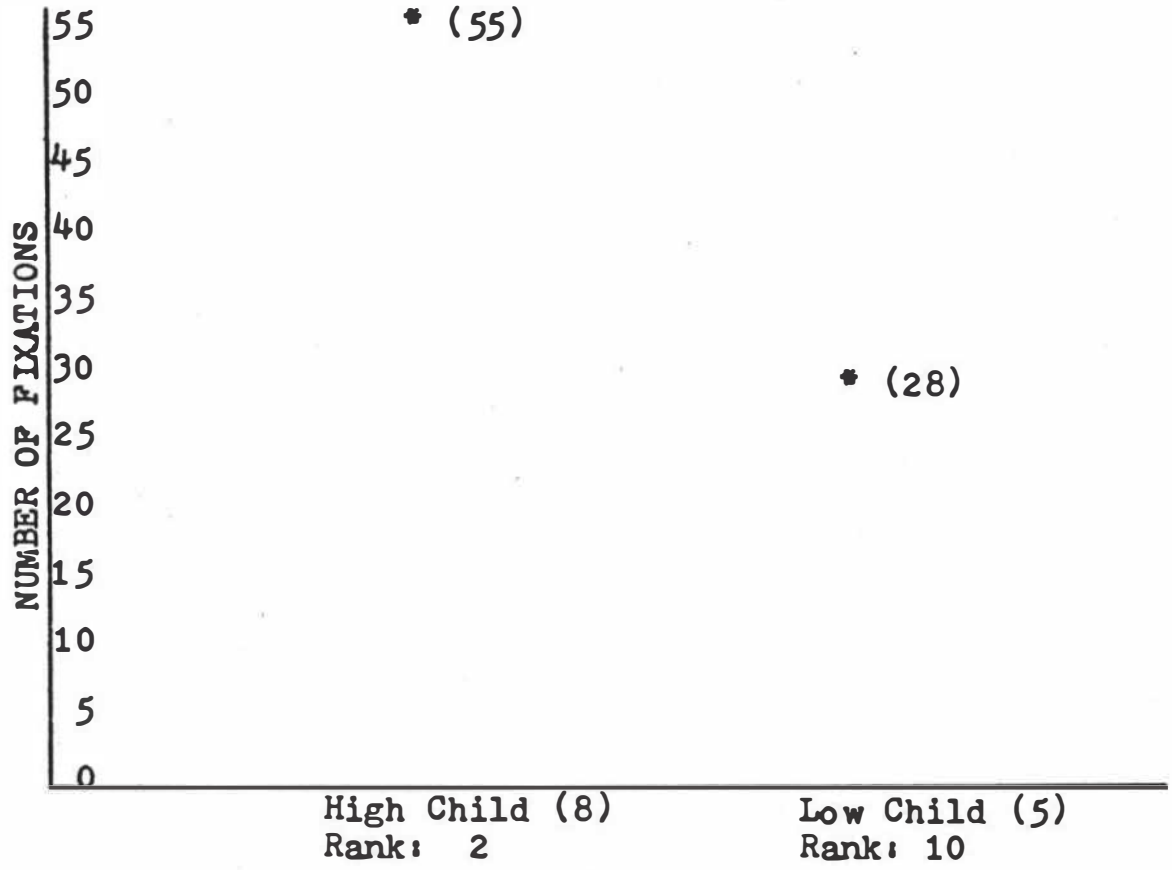

Figure 1. Number of Fixations for Subject 1.

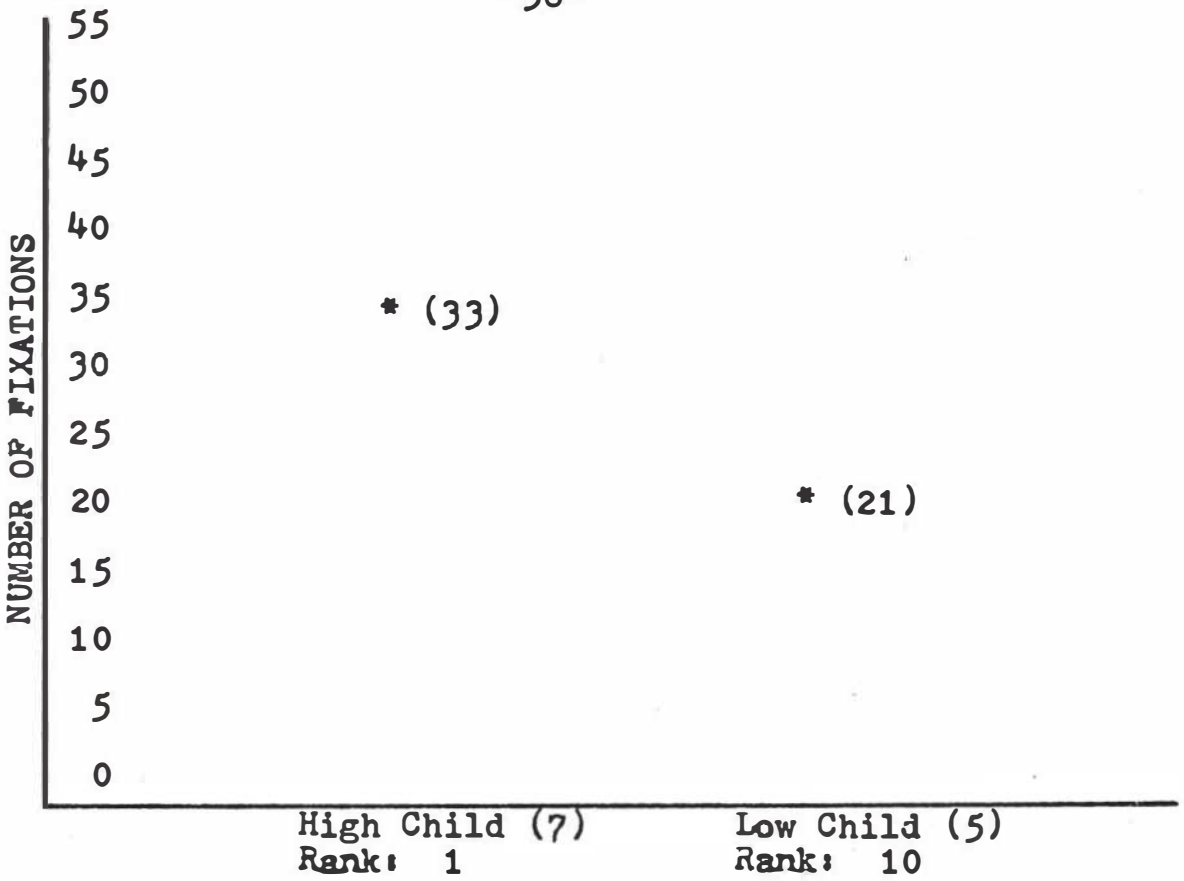

Figure 2. Number of Fixations for Subject 2.

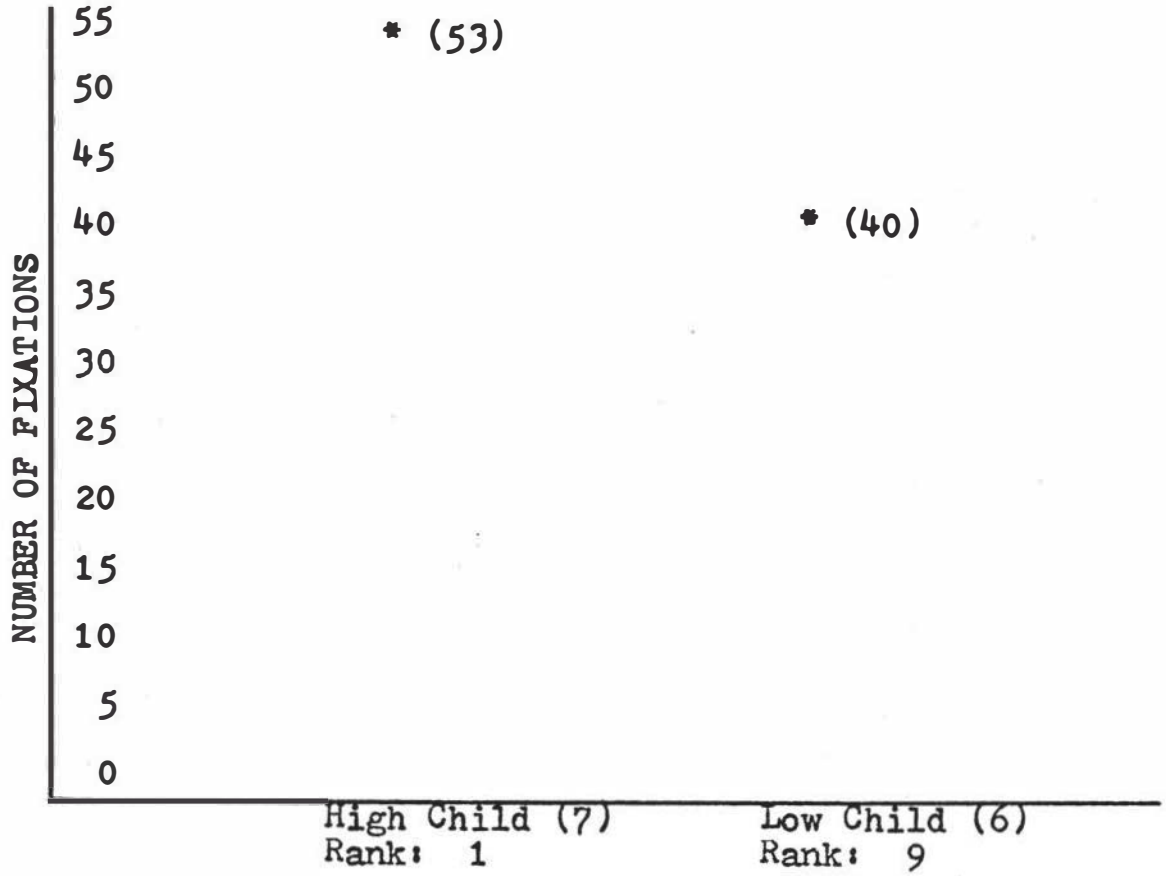

Figure 3. Number of Fixations for Subject 3.

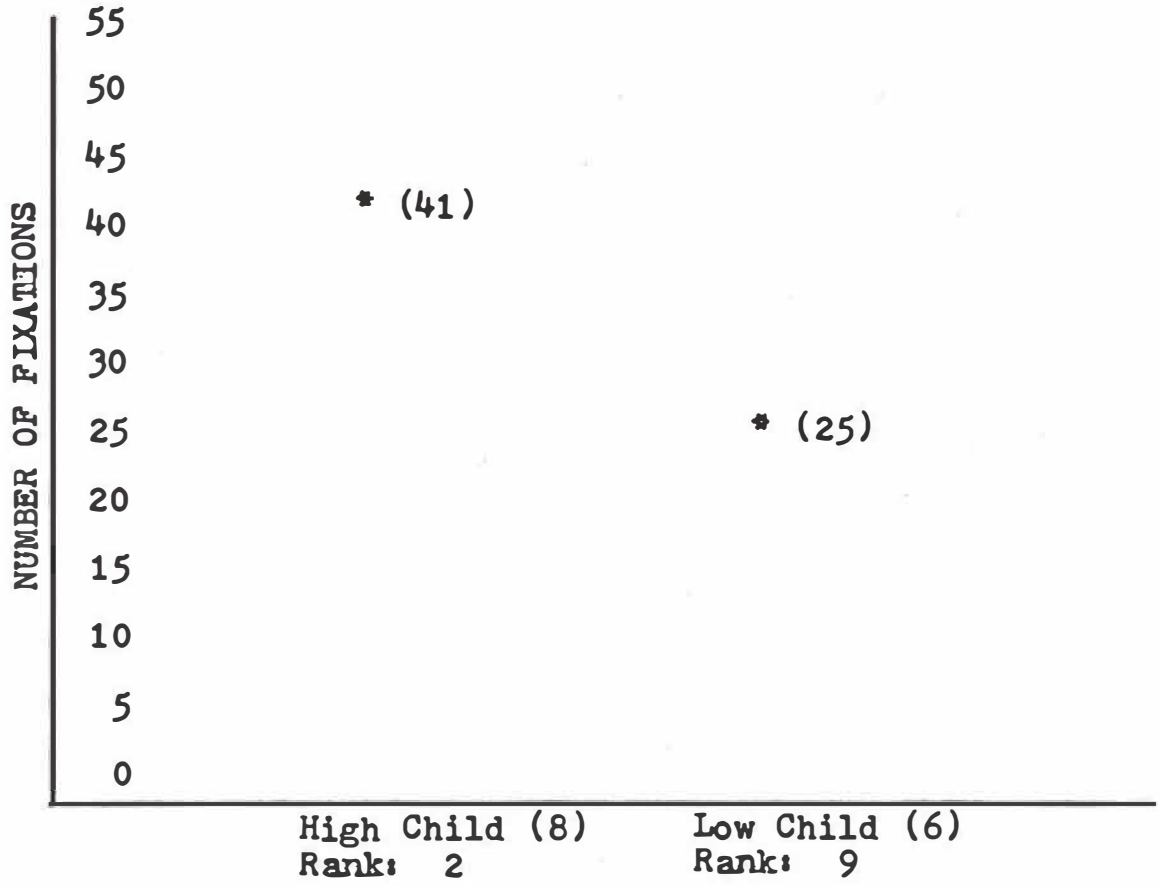

Figure 4. Number of Fixations for Subject 4.

As can be seen in Figures 1 through 4, the picture sequences in the High Child category received a greater frequency of fixations than those in the Low Child category. This was true of all the subjects. In order to determine if the observed frequencies for the High Child and Low Child sequences were drawn from the same population, the procedures outlined by Downie and Heath (1965) were used to compute the Mann-Whitney U. A U value of 1 was obtained and the level of the significance of difference was 0.03. That is to say that the behavior of the subjects in terms of frequency of fixations while viewing High Child sequences was significantly different from their behavior while viewing the Low Child sequences.

Clearly a consistent relationship exists between the psychological scale values and the number of fixations for the child-generated sequences. As stated in Chapter II, a child makes more

fixations as a function of his obtaining more information from a visual display. Information, as the term will be used here, is directly related to the uncertainty for the child in the display causing him to make more fixations. It is hypothesized that the subjects in this investigation were obtaining more information from the High Child picture sequences than they were from the Low Child picture sequences. This finding is consistent with all the subjects and consistent with the Kingery study (1972). The Kingery study concluded that children agree highly among themselves as to what constitutes a visually literate child-generated sequence. This conclusion was based on the reliability of the children's psychological scale values for the child-generated sequences. The frequency of fixation varied uniformly among the subjects but the High-Low split was a consistently observed trend regardless of level. The fact that the frequency levels varied among the subjects can be interpreted to mean that each subject had a different way of looking at the picture sequences. Some subjects may have needed to make more fixations in order to grasp the meaning or significance of a feature than did other subjects. The results of the present study tend to corroborate those of the previous study. The subjects consistently made more fixations on the High Child picture sequences than on the Low Child picture sequences and this was significant at the 0.05 level of confidence.

II. Frequency of Fixations for Adult-Generated Sequences

The following figures illustrate the frequency of fixations for each subject as he viewed the adult-generated picture sequences.

As with the child-generated sequences, the adult-generated sequences were divided into two categories. The High Adult sequences consisted of picture sequence numbers sixteen and twelve. These sequences ranked the highest and second highest, respectively, of the adult-generated sequences when psychologically scaled by children in the Kingery (1972) study. The Low Adult sequences consisted of sequence numbers seventeen and eleven. These sequences ranked ninth and tenth, respectively, for the adult-generated sequences when psychologically scaled by children in the Kingery study. Each of the four subjects viewed one sequence in each category; therefore, each sequence was viewed twice, once by each of two subjects. The table below illustrates the sequence numbers from the Kingery study seen by each subject in the present investigation.

TABLE III

ADULT-GENERATED SEQUENCES VIEWED BY EACH SUBJECT

Subject	High Adult	Low Adult
1	12	17
2	16	17
3	16	11
4	12	11

For the figures below the sequence number is entered in parentheses along the abscissa with its ranking below it.

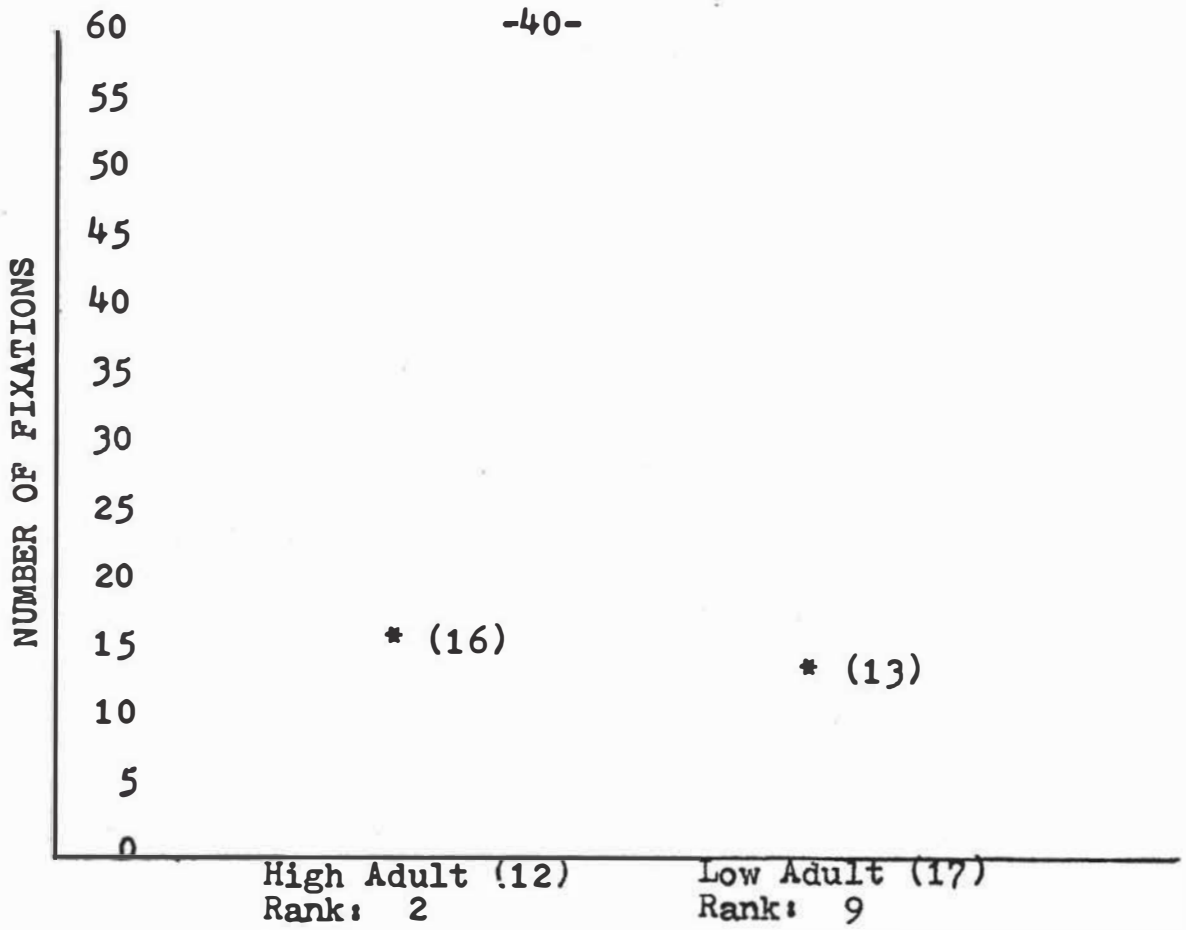

Figure 5. Frequency of Fixation for Subject 1.

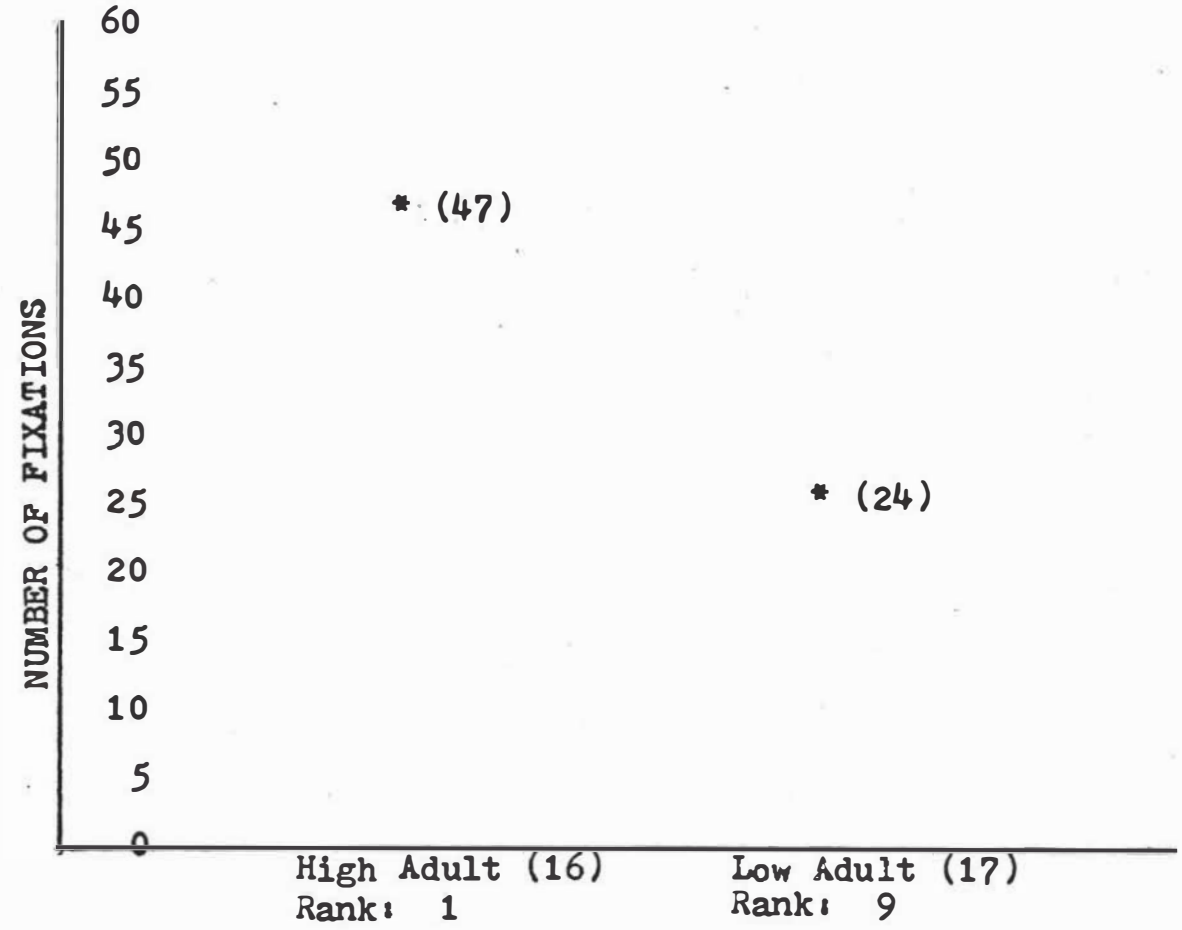

Figure 6. Frequency of Fixation for Subject 2.

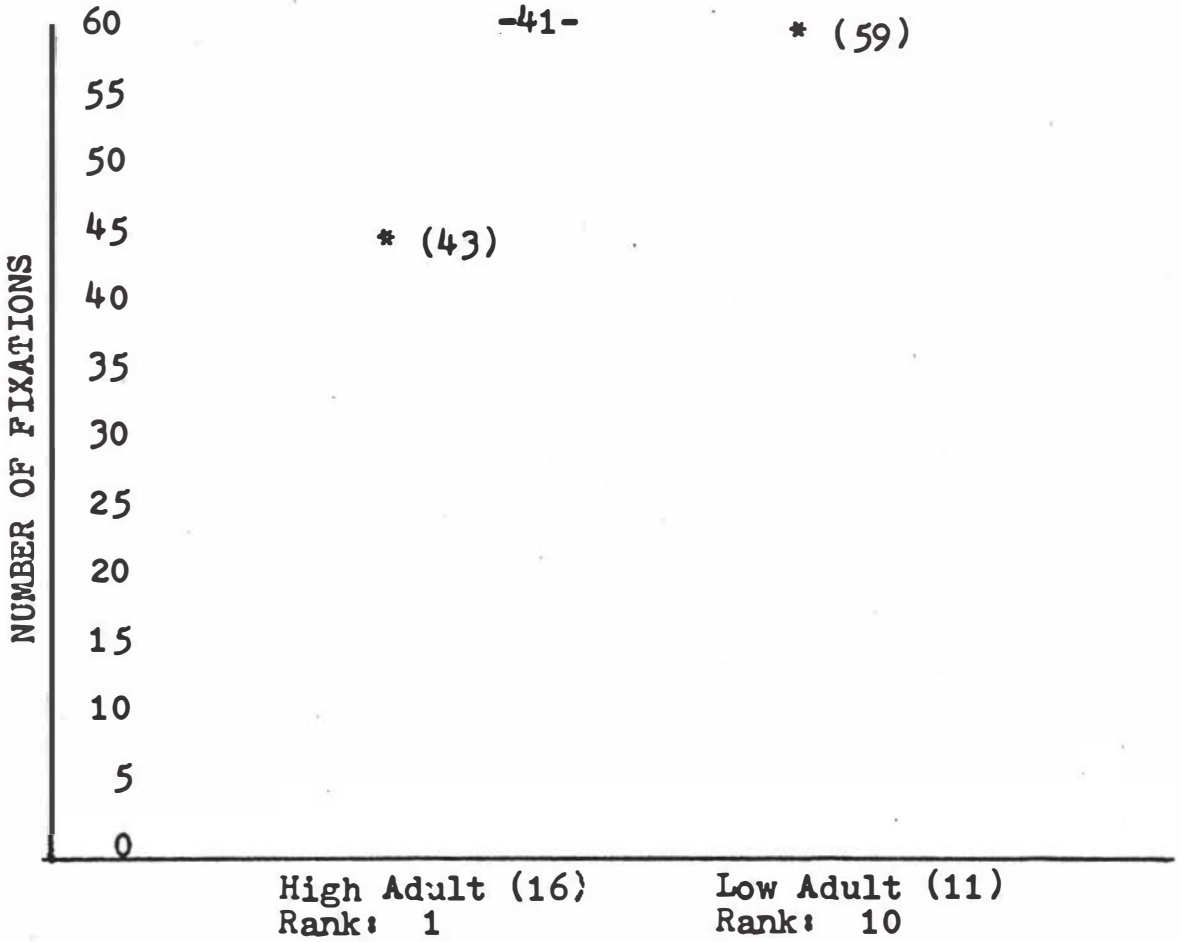

Figure 7. Frequency of Fixation for Subject 3.

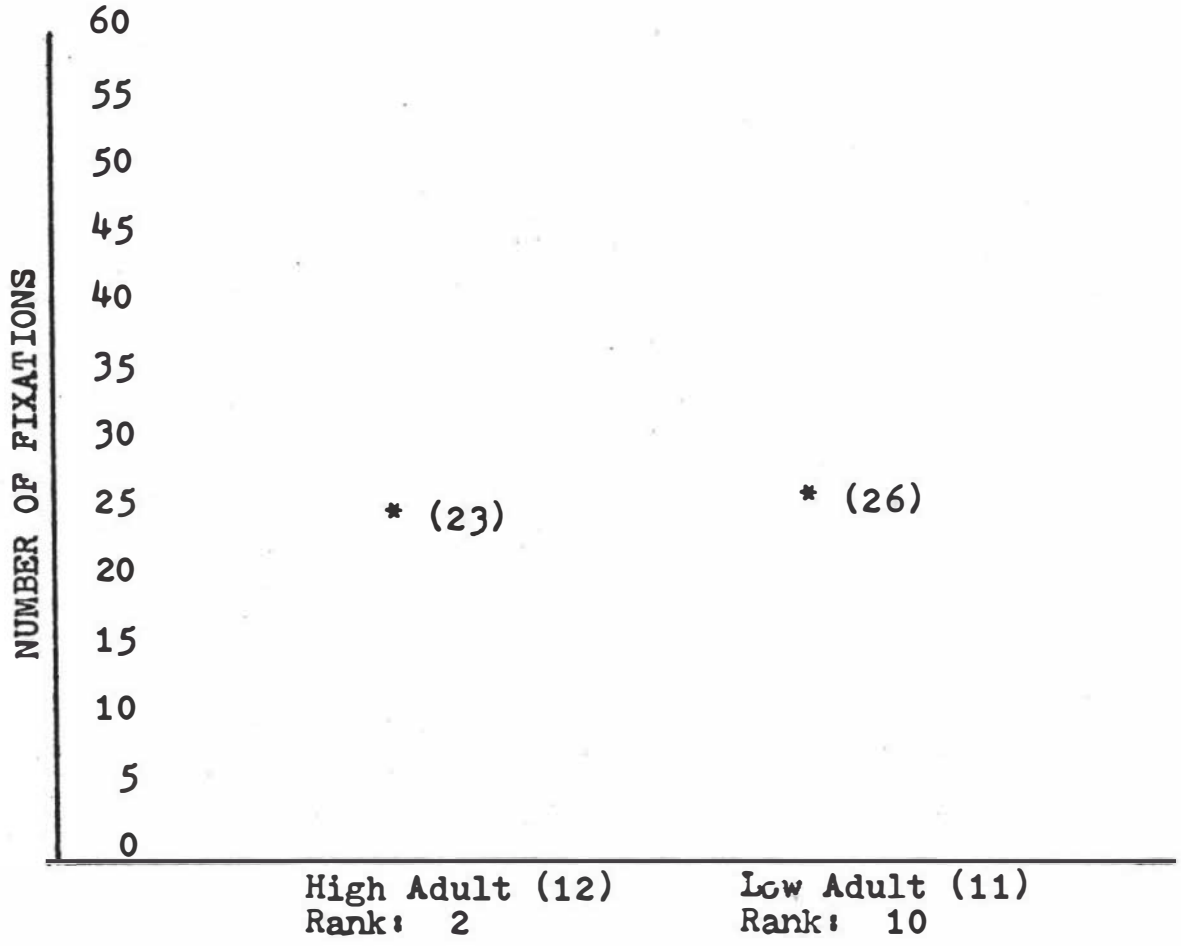

Figure 8. Frequency of Fixation for Subject 4.

As can be seen from Figures 5 and 6, two subjects made more fixations on the High Adult sequences and two made more fixations on the Low Adult sequences as is indicated in Figures 7 and 8. Previous research has concluded that children do not agree as highly about what constitutes a visually literate adult-generated picture sequence as about what constitutes a visually literate child-generated sequence. This conclusion was based on the reliability of the children's rank orderings of adult-generated sequences in the Kingery (1972) study. The subjects' physiological responses to adult-generated visual material was not as consistent as it was for the child-generated visual material. This suggests that the content of the adult visual materials generates a variability in subjects' responses. What is meaningful in an adult sequence for one child may not be meaningful to another child. It can be hypothesized that varying amounts of information were obtained by the subjects, suggesting that the degree of informativeness was also variable.

Again a Mann-Whitney U was computed to determine if a significant difference existed between the observed frequencies for High Adult and Low Adult picture sequences. A confidence level of 0.05 was set as acceptable for statistical significance. A U value of 8 was obtained and the level of the significance of difference was 0.56. That is to say, the subjects' behaviors on the High Adult sequences in terms of number of fixations was not significantly different from their behavior on the Low Adult sequences. The subjects' behaviors can, therefore, be attributed only to chance.

III. Comparison of Frequency of Fixation for Child-Generated and Adult-Generated Picture Sequences

The following figures (Figures 9 through 12) give a total view of each subject's performance with regard to frequency of fixation while comparing adult-generated and child-generated sequences.

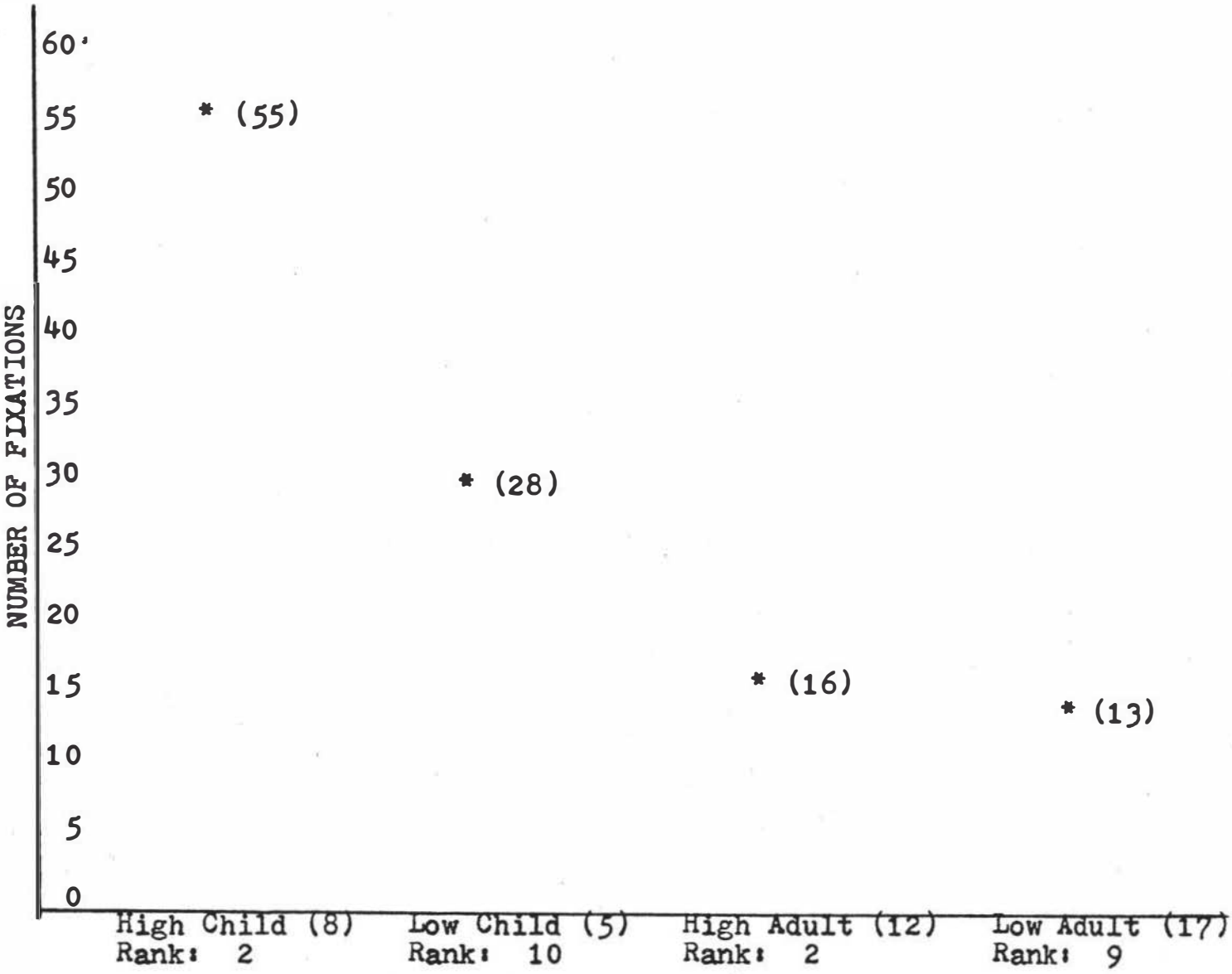

Figure 9. Total Frequency of Fixation for Subject 1.

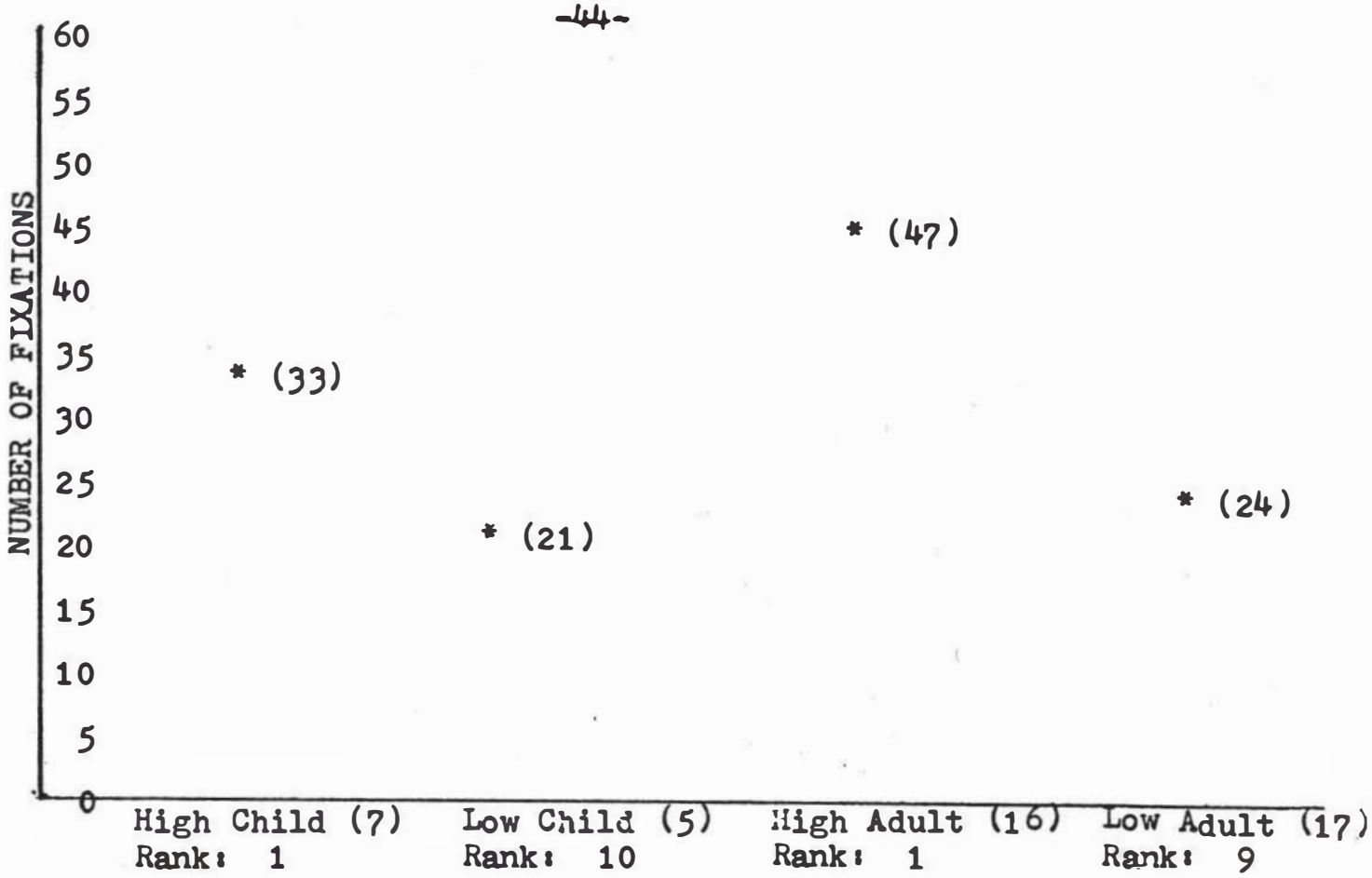

Figure 10. Total Frequency of Fixation for Subject 2.

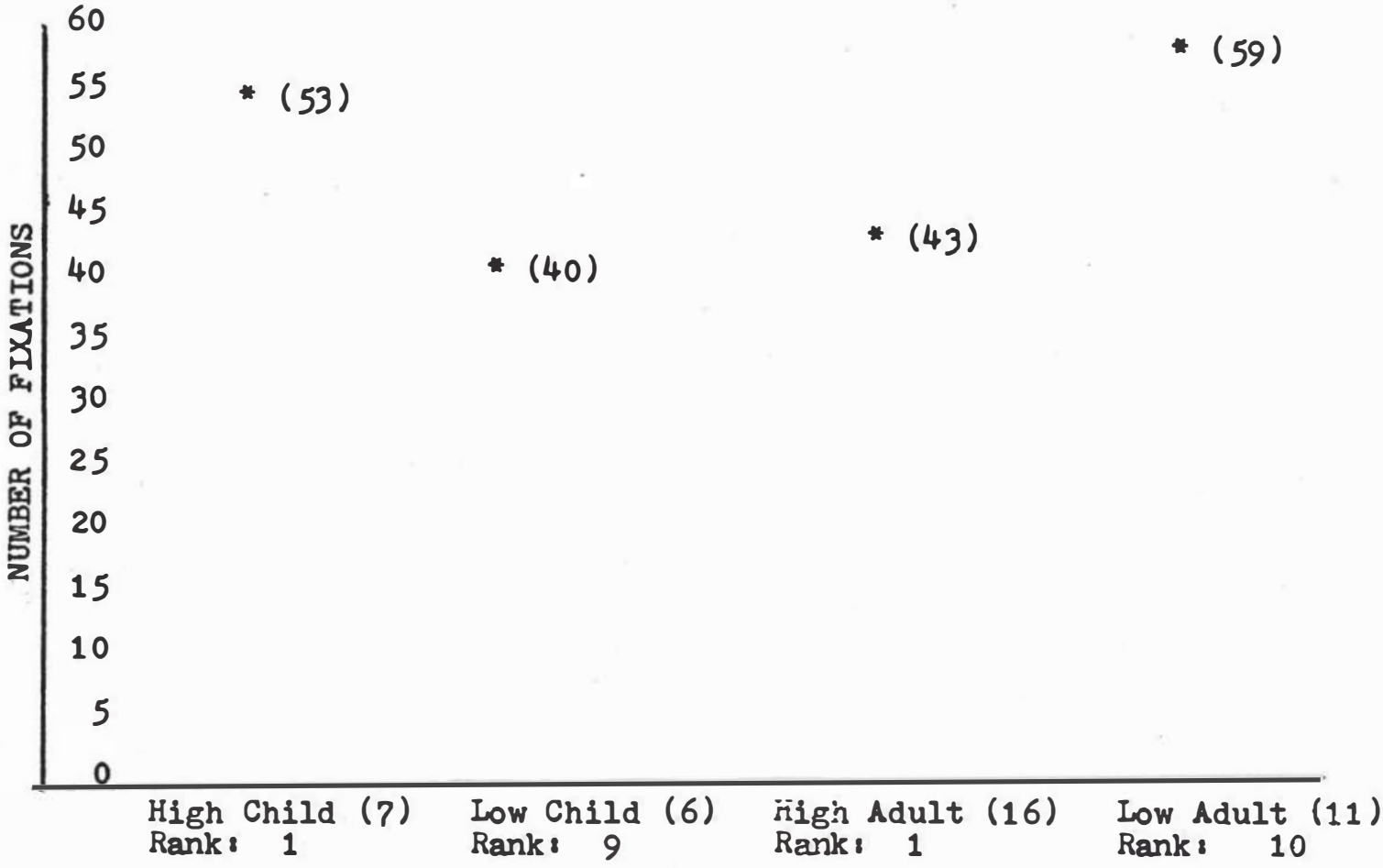

Figure 11. Total Frequency of Fixation for Subject 3.

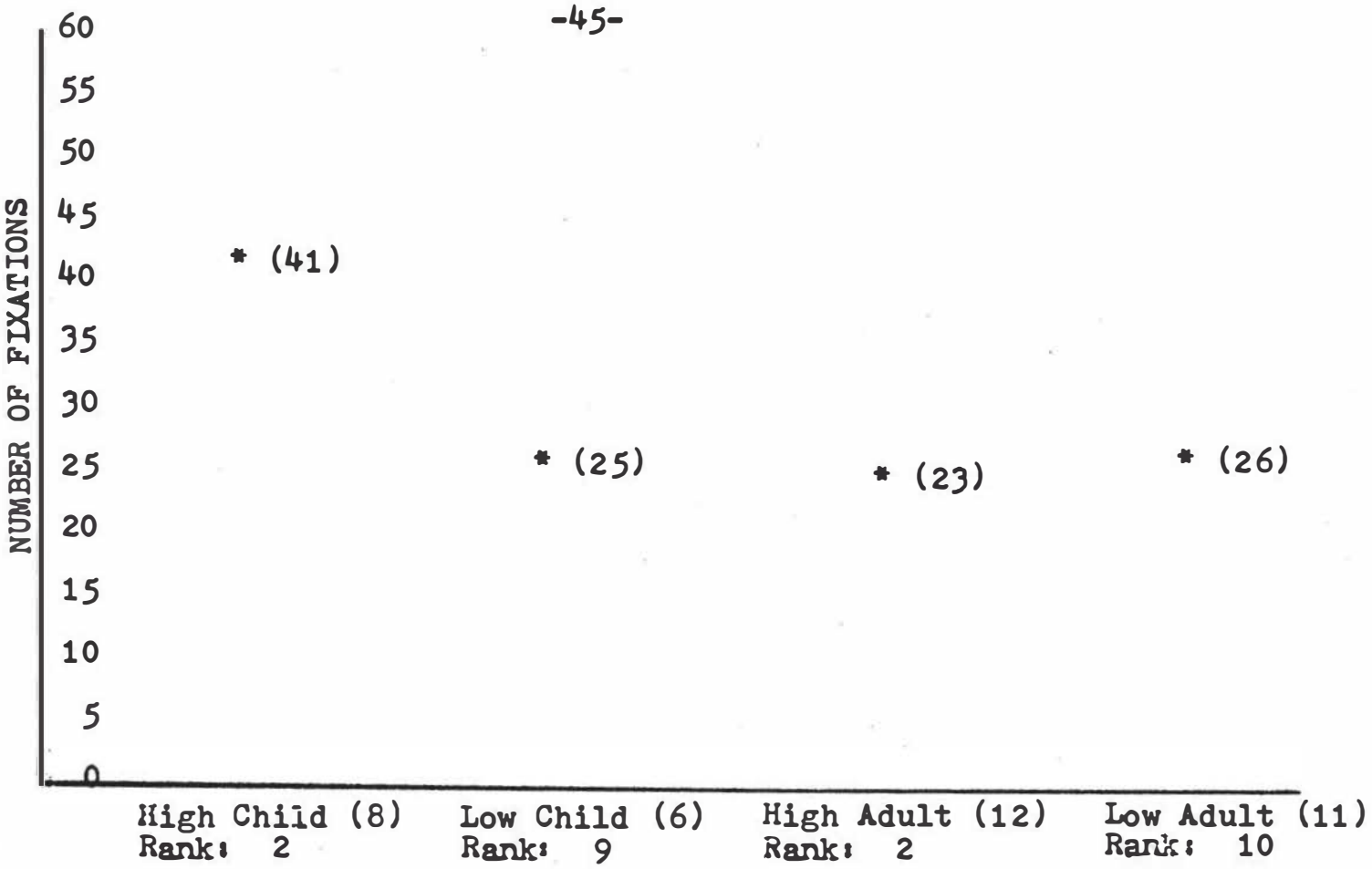

Figure 12. Total Frequency of Fixation for Subject 4.

When all the sequences are considered together the choice of one sequence category to be attended to over another is not consistent among the subjects. This is not surprising considering the variability of response to the adult-generated sequences. Two of the subjects made more fixations for the High Child picture sequences than the other categories while one made more fixations for the High Adult and one for the Low Adult category. From these statements one might assume that the observed baseline behavior is in a steady state. The variables that are being held quantitatively constant, however, do not necessarily exert a constant effect throughout all phases of the experiment. The observed frequencies may be a result of the intrinsic variability of the baseline behavior.

As previously stated a significant difference exxisted between the subjects' behavior on the High Child and Low Child picture sequences but did not exist between their behavior on the adult sequences. A Mann-Whitney U was computed to determine if a significant difference existed between the other categories. Table IV below gives the compare categories, the U value and the level of significance obtained. A significance level of 0.05 was again set.

TABLE IV

MANN-WHITNEY U VALUES FOR FREQUENCY OF FIXATION

Compared Categories	U Value	Level Required	Level Obtained
High Child-Low Child	1	0.05	0.03
High Adult- Low Adult	8	0.05	0.56
High Child-High Adult	4	0.05	0.17
High Child-Low Adult	4	0.05	0.17
Low Child-High Adult	8	0.05	0.56
Low Child-Low Adult	7	0.05	0.43

As can be seen from the table, the only two categories that were significantly different from each other are High Child and Low Child. That is to say that the subjects' behaviors between any two of the other categories was not different from each other. The subjects did prefer the High Child over the Low Child picture sequences but their preference with regard to other categories was merely chance.

IV. Duration of Fixation for Child-Generated Picture Sequences

Essentially the same procedures for describing the frequency of fixation will be used for describing the duration of fixation.

The number of frames the child's eye was fixated to a point for each sequence was multiplied by .056 seconds, the time represented by one frame. Thus, a value in seconds was determined as the total duration of fixation for each sequence. Again the child-generated sequences were divided into High Child and Low Child categories. The following figures illustrate the duration of fixation made by each subject for the child-generated picture sequences. The number of the sequence is entered in parentheses along the abscissa with its ranked value below it.

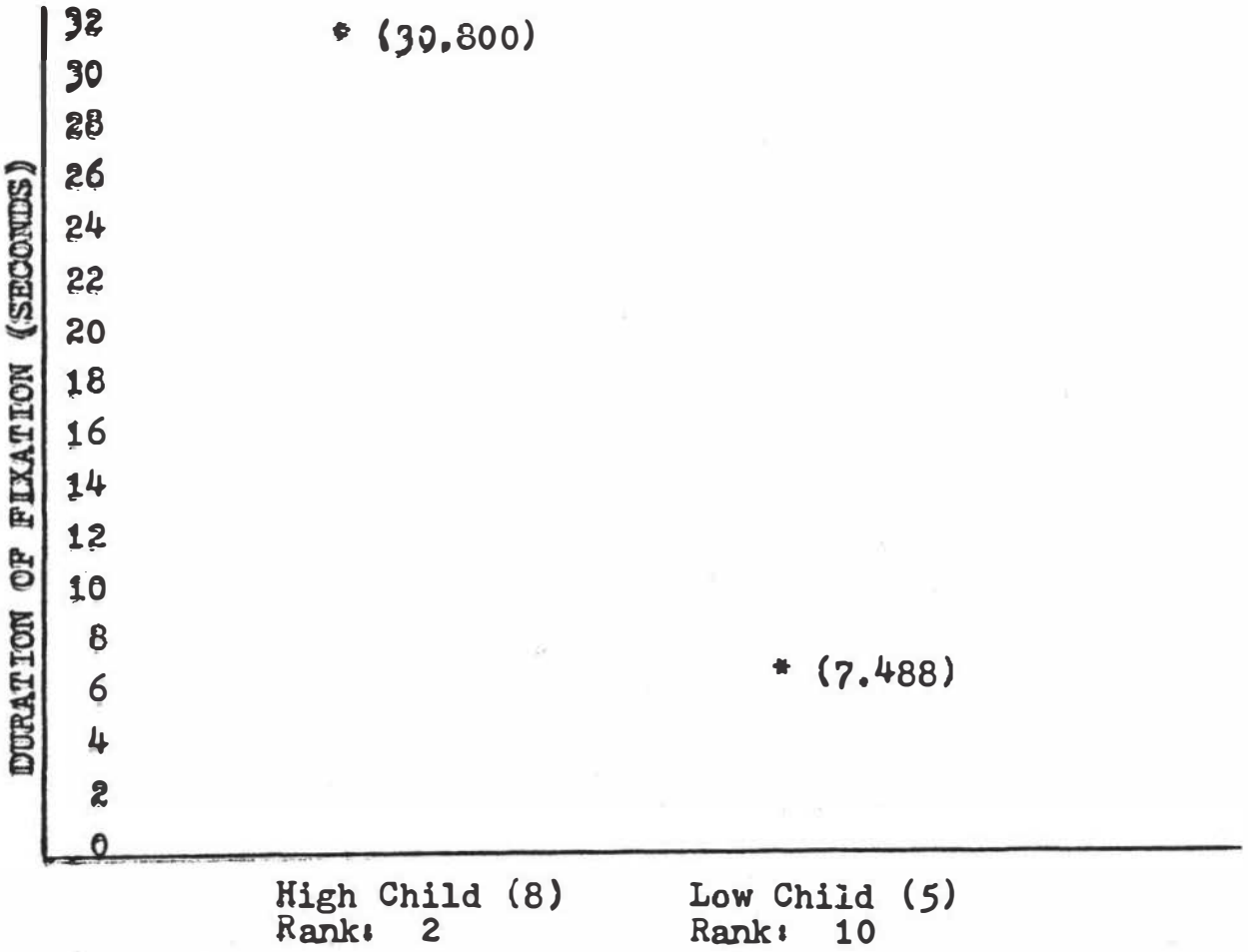

Figure 13. Duration of Fixation for Subject 1.

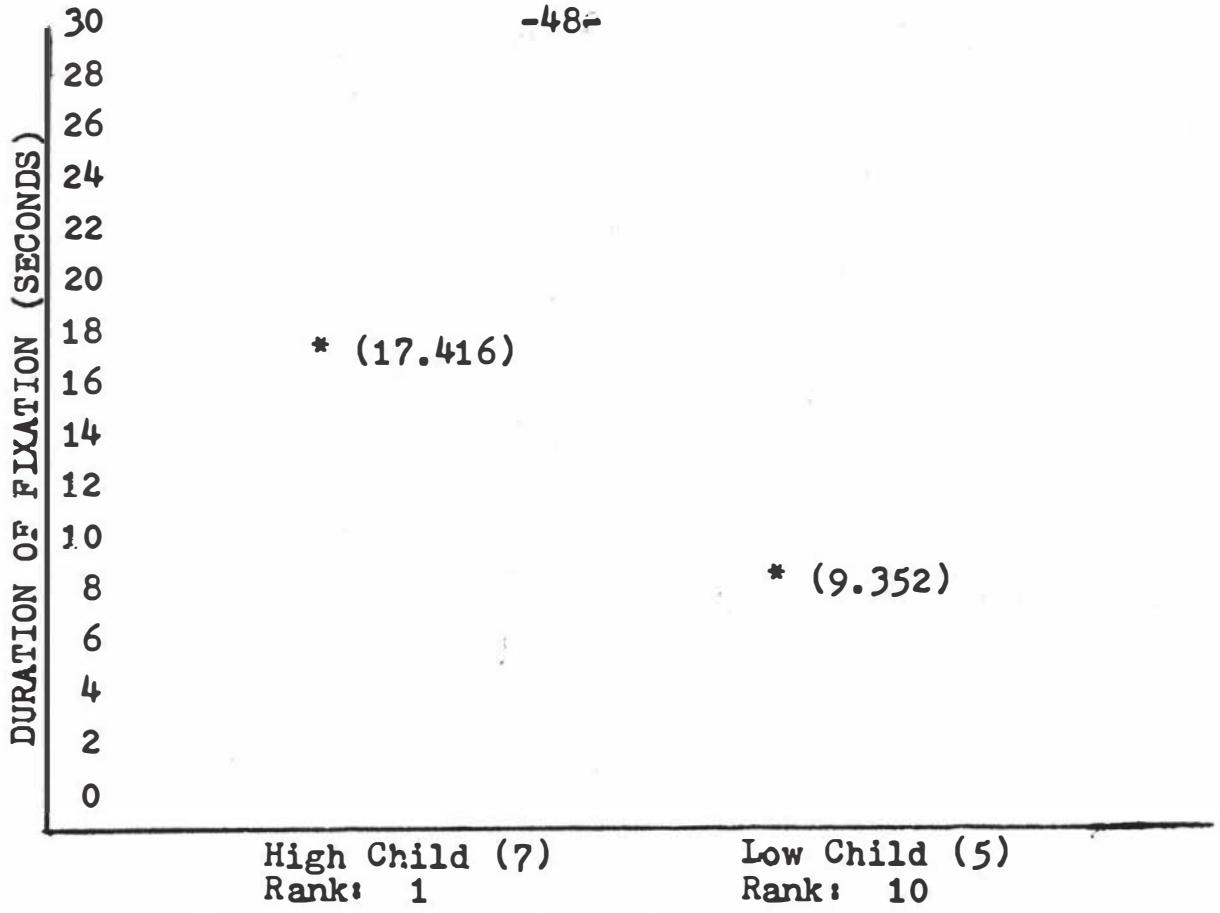

Figure 14. Duration of Fixation for Subject 2.

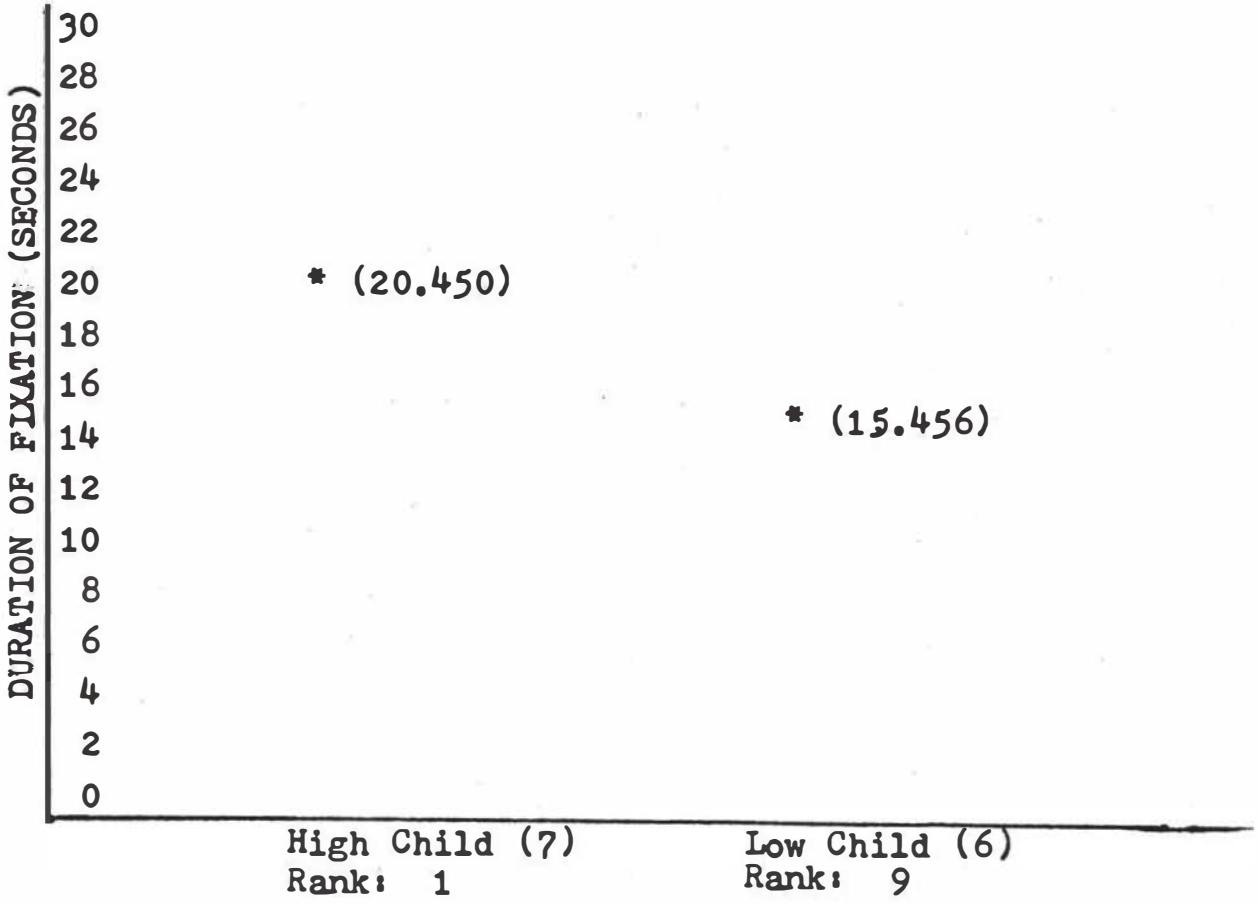

Figure 15. Duration of Fixation for Subject 3.

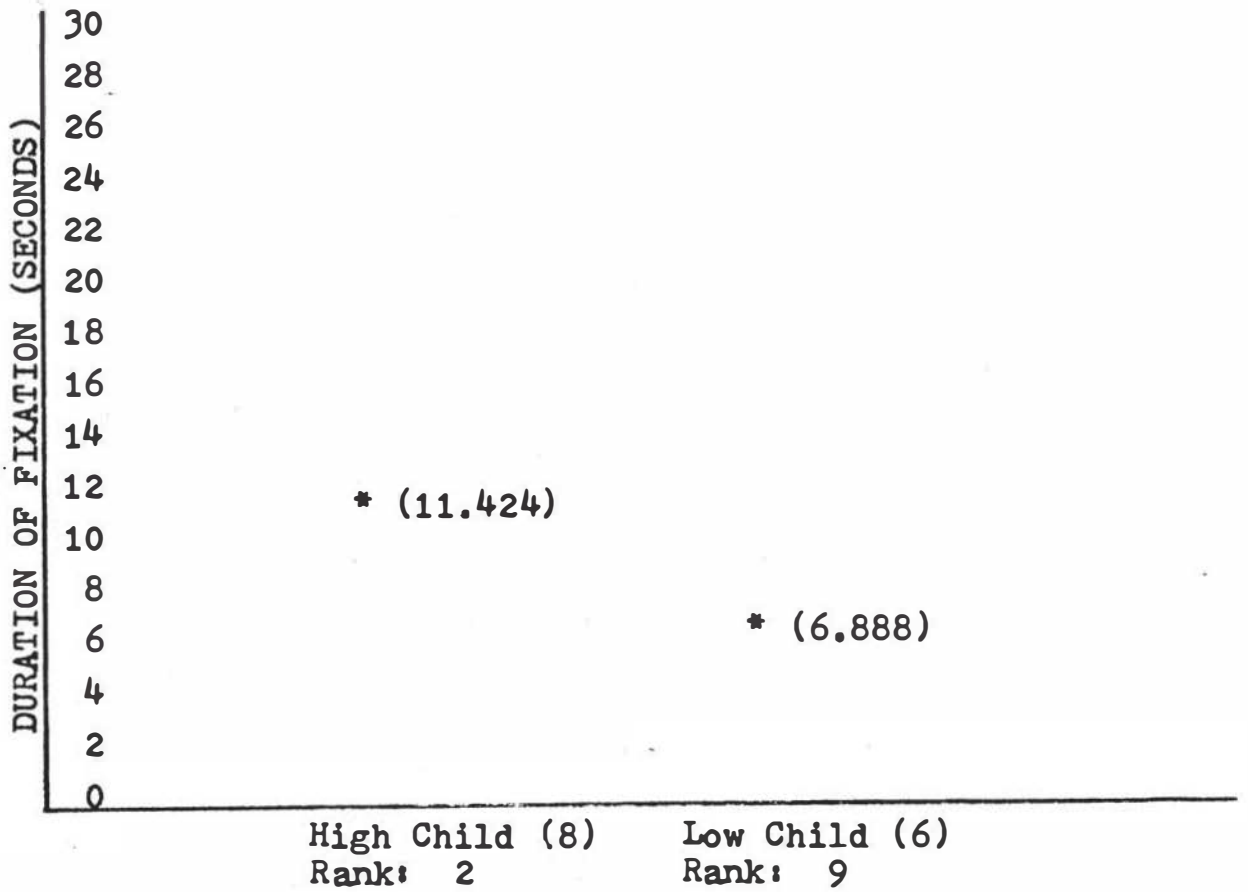

Figure 16. Duration of Fixation for Subject 4.

All four subjects spent more time fixating on the High Child picture sequences than the Low Child picture sequences. This suggests that more information was being obtained from the child sequences which had a higher ranked psychological value. This lends further support to the previous findings that children agree highly among themselves as to what constitutes a visually literate child-generated sequence. The graphic display for duration of fixation essentially mirrors that for number of fixations for child-generated sequences. With the test variables being the same for both measures, this suggests that both frequency and duration are not only measuring the same variable, amount of information being obtained from child-generated sequences, but are measuring it to nearly the same degree.

V. Duration of Fixation for Adult-Generated Picture Sequences

The following figures illustrate the duration of fixation for adult-generated picture sequences. As stated previously, the values for duration of fixation were obtained by totaling the number of frames the eyes were fixated for each sequence and multiplying by .056 seconds. The value represents the total amount of time spent by each subject fixating the features of an adult-generated sequence. Again the sequences were divided into two categories, High Adult and Low Adult. The number of the sequence is entered in parentheses with its ranked value below it.

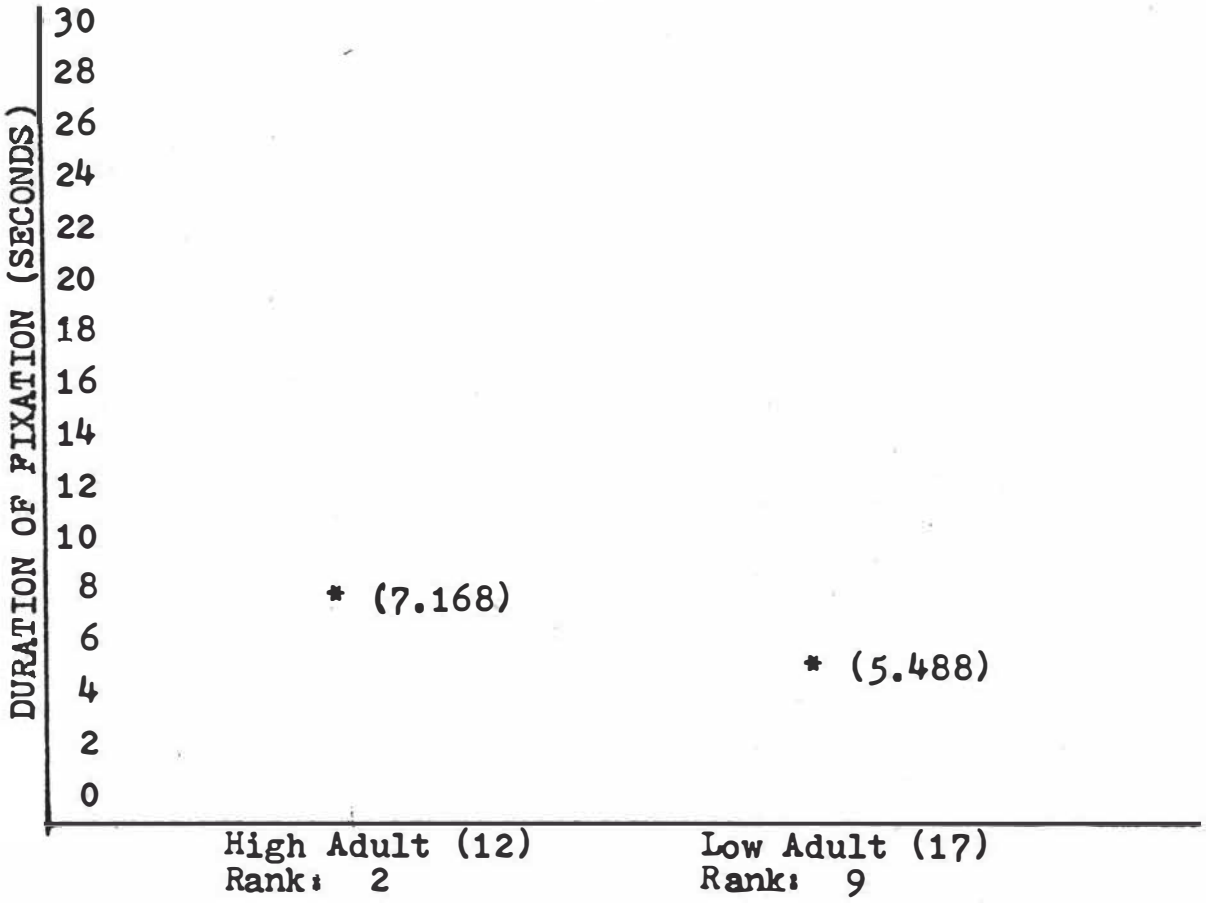

Figure 17. Duration of Fixation for Subject 1.

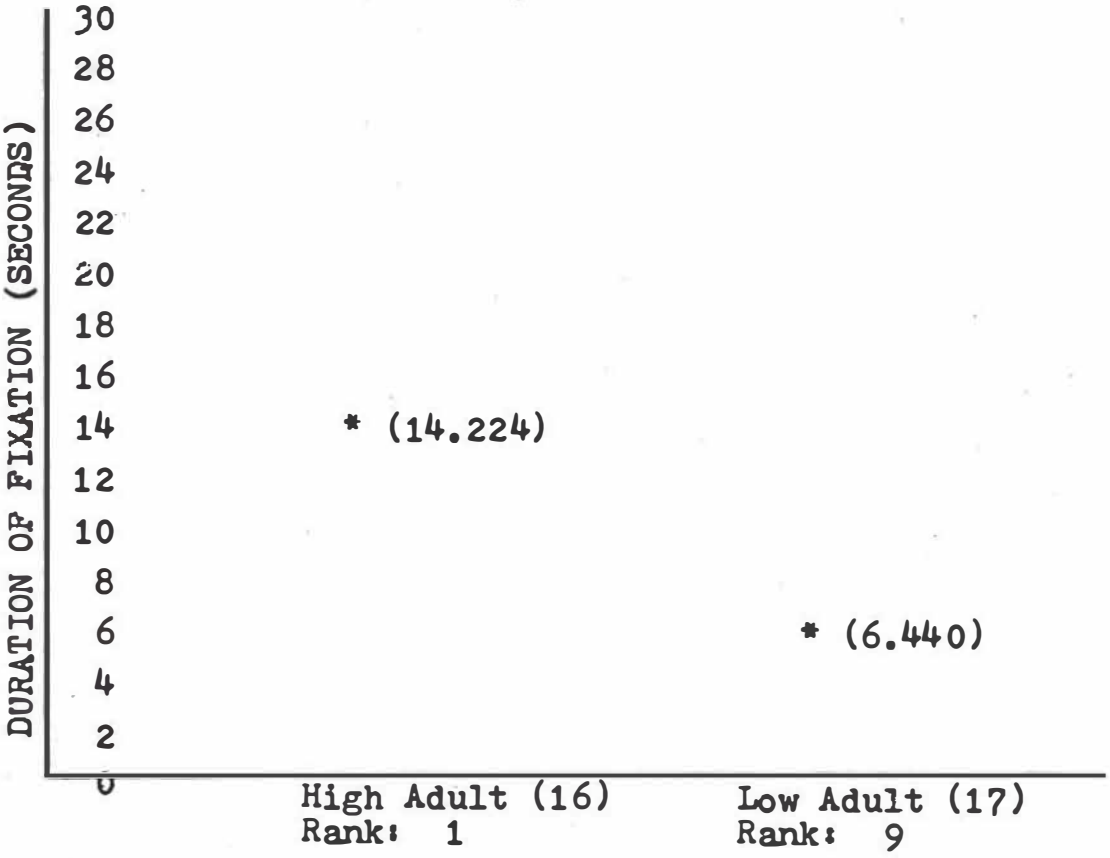

Figure 18. Duration of Fixation for Subject 2.

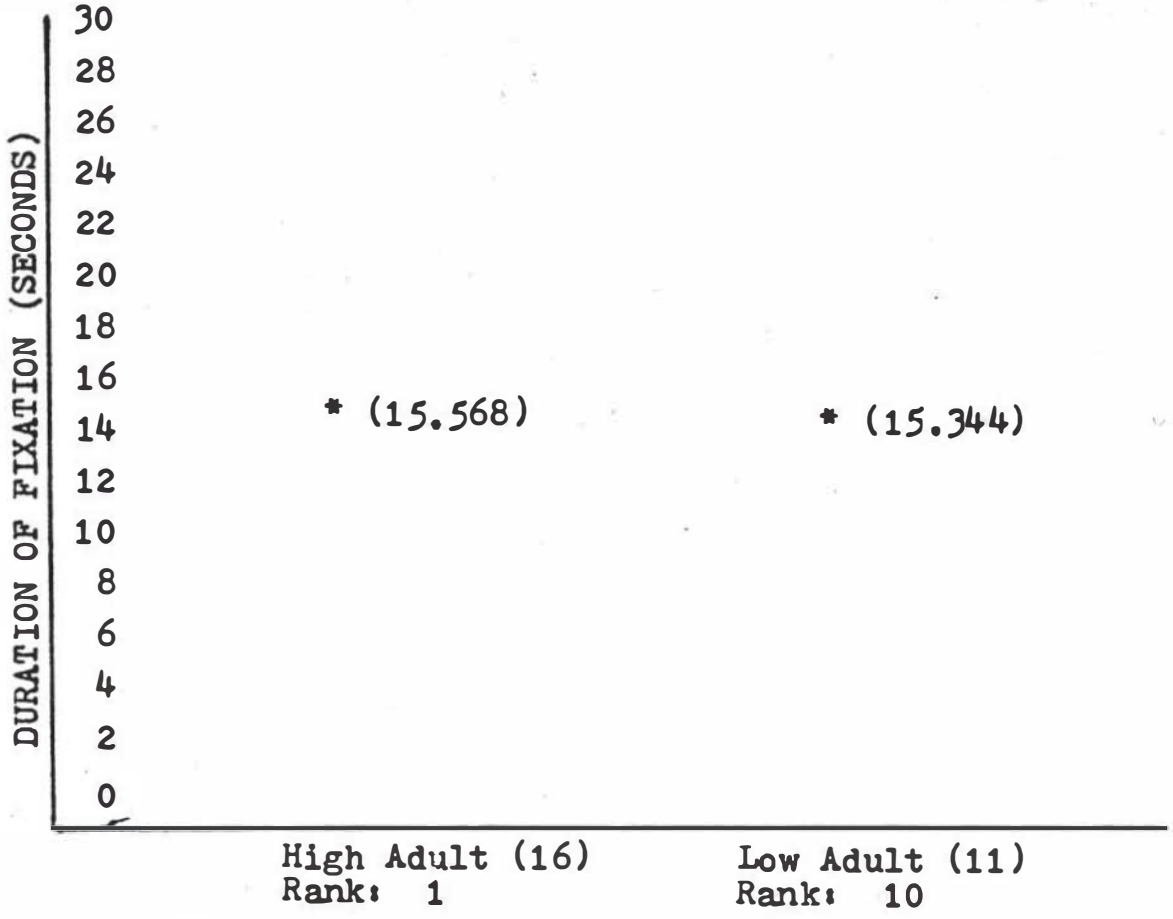

Figure 19. Duration of Fixation for Subject 3.

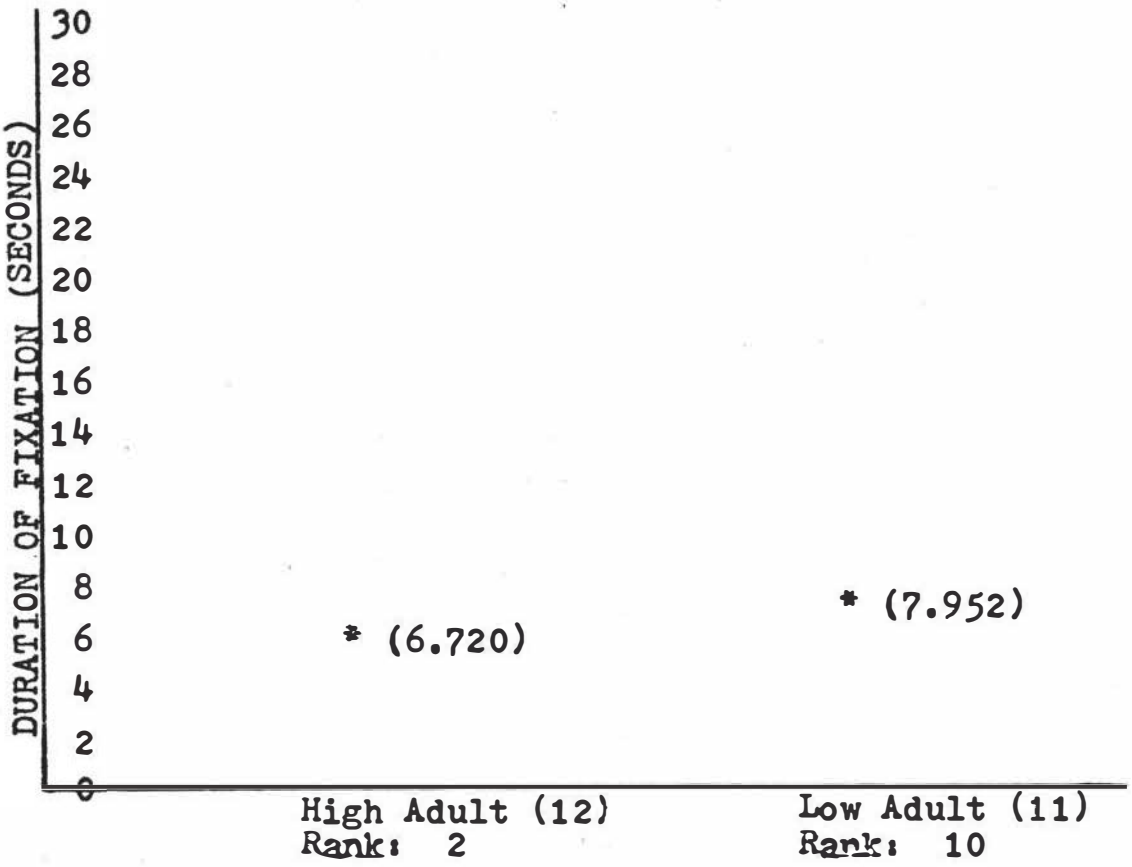

Figure 20. Duration of Fixation for Subject 4.

Three of the subjects fixated the High Adult picture sequences for a longer period of time than the Low Adult picture sequences. The fourth subject fixated the Low Adult picture sequence longer than the High Adult picture sequence by little over a second. Although there appears to be a trend to fixate longer on the High Adult sequences this was not true for all subjects. Variability in response to adult-generated materials is present in the duration of fixation as well as the frequence of fixation.

VI. Comparison of Duration of Fixation for Child-Generated and Adult-Generated Picture Sequences

The following figures give a total view of each subject's performance with regard to duration of fixation. The measurement is once again in seconds.

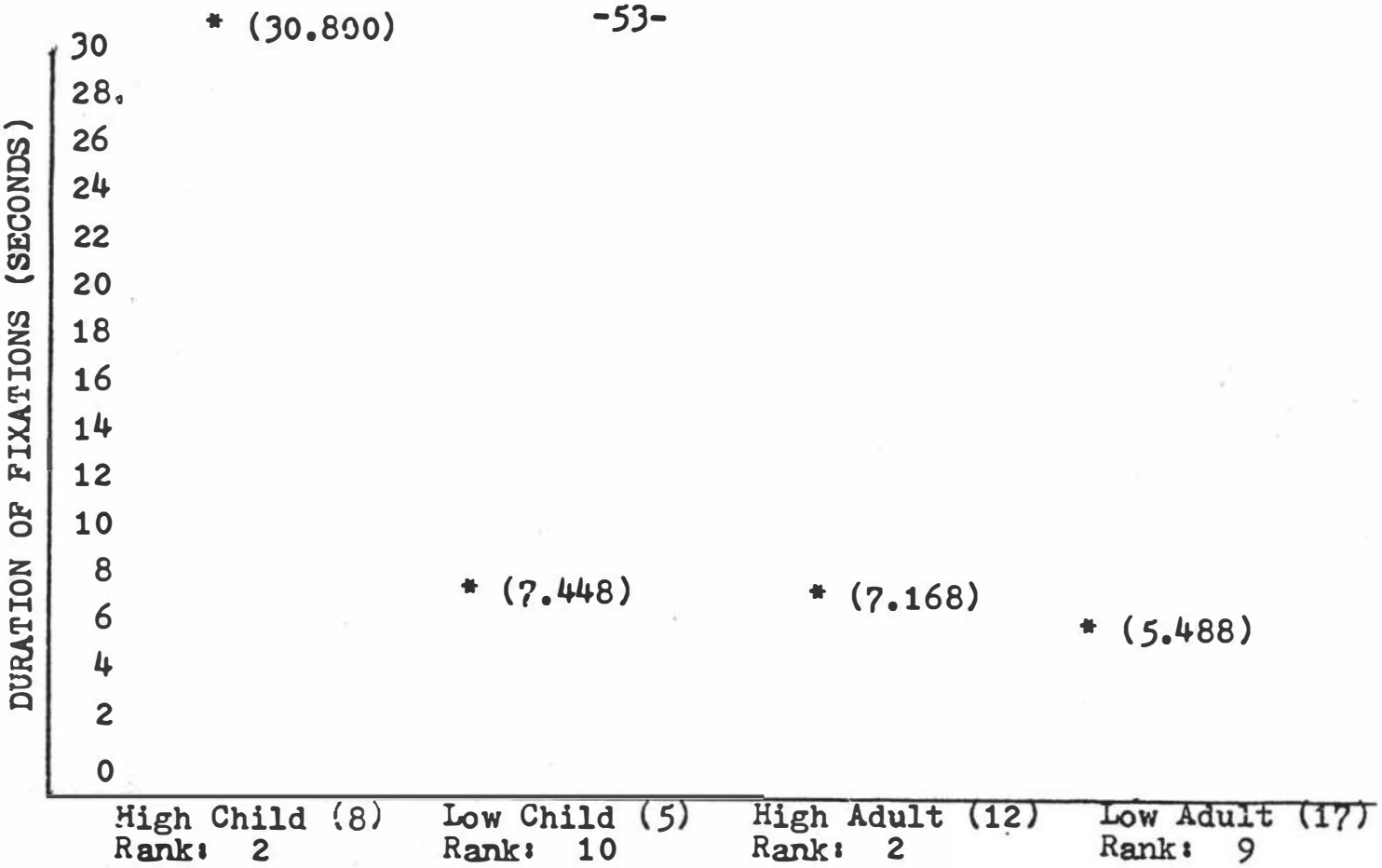

Figure 21. Total Duration of Fixation for Subject 1.

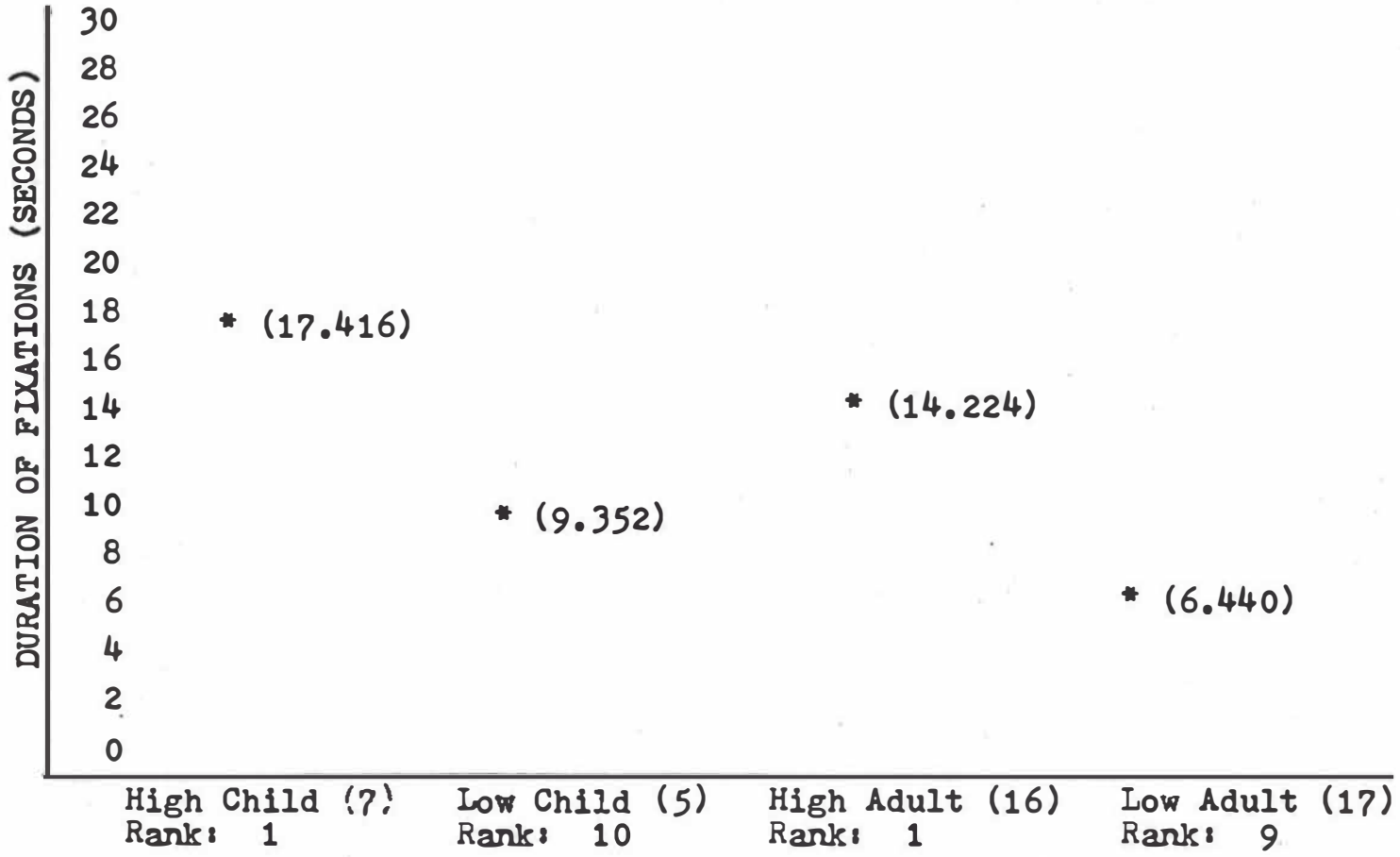

Figure 22. Total Duration of Fixation for Subject 2.

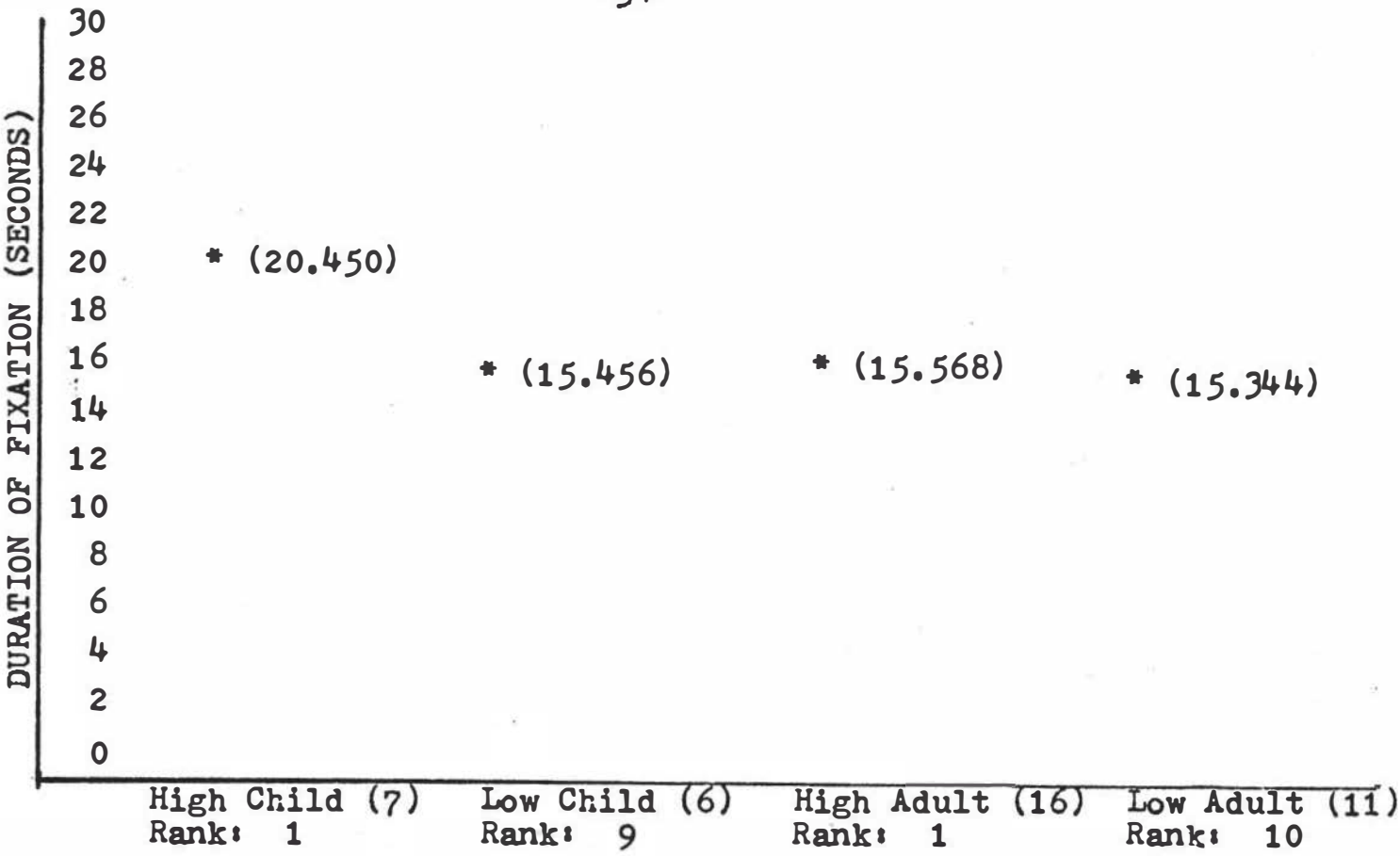

Figure 23. Total Duration of Fixation for Subject 3.

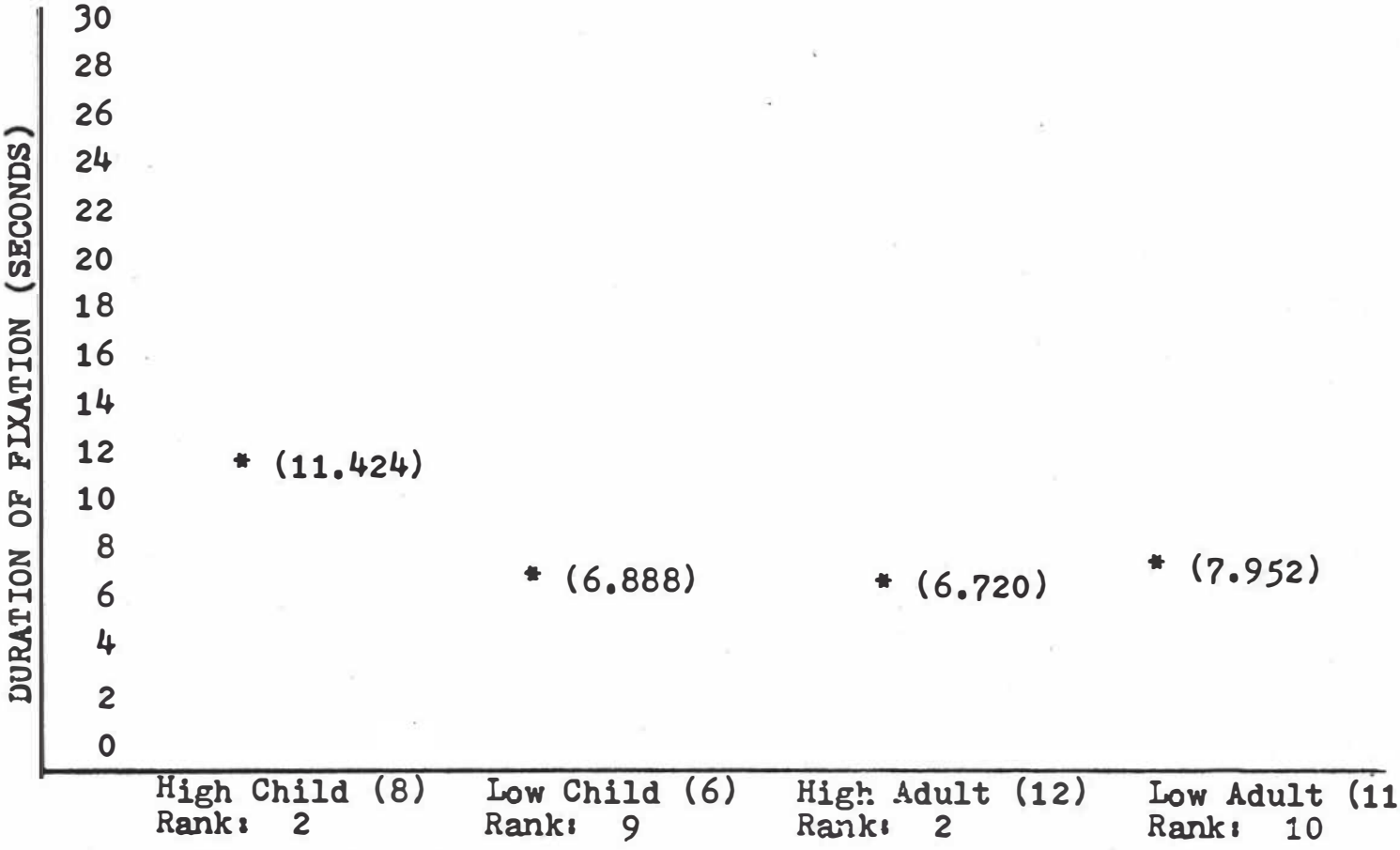

Figure 24. Total Duration of Fixation for Subject 4.

All the subjects fixated the High Child pictures sequences for longer periods of time than any other category. Clearly, then, more information was being obtained from these picture sequences. The category of picture sequences on which the next highest amount of time was spent fixating varied. After the High Child category two subjects spent more time fixating the High Adult category, one the Low Child category and one the Low Adult category.

As with the frequency of fixation a Mann-Whitney U was computed to determine whether significant differences between the subjects' behaviors with regard to duration of fixation existed between any two categories. The following table gives the compared categories, the U value and the level of significance obtained. A level of 0.05 was set as being significantly different.

TABLE V

MANN-WHITNEY U VALUES FOR DURATION OF FIXATION

Compared Categories	U Value	Level Required	Level Obtained
High Child-Low Child	1	0.05	0.03
High Adult-Low Adult	5	0.05	0.24
High Child-High Adult	2	0.05	0.06
High Child-Low Adult	1	0.05	0.03
Low Child-High Adult	8	0.05	0.56
Low Child-Low Adult	5	0.05	0.24

As can be seen from Table V, a significant difference in behavior existed between the High Child and Low Child and between the High Child and Low Adult categories. The subjects preferred the High Child over the Low Child and the High Child over the Low Adult. Their behavior with regard to the other categories was existing on the chance level.

VII. Percentage of Total Viewing Time Spent Fixating

The total viewing time spent on each picture sequence was determined by multiplying the number of frames filmed for each subject as they viewed a picture sequence by .056 seconds. The amount of time a subject looked away from the sequence for such as looking at the examiner, looking in the mirror or rubbing their eyes was subtracted from the total time. Thus the total viewing time included only the duration of fixations and the time spent by the child scanning the picture sequence. A percentage of viewing time spent fixating was obtained by dividing the total duration of fixation for a sequence by its total viewing time and multiplying by one hundred. Figures 25 through 28 show the percentage of total viewing time spent fixating each picture sequence. Again each picture was placed in its appropriate category and its ranked value is listed.

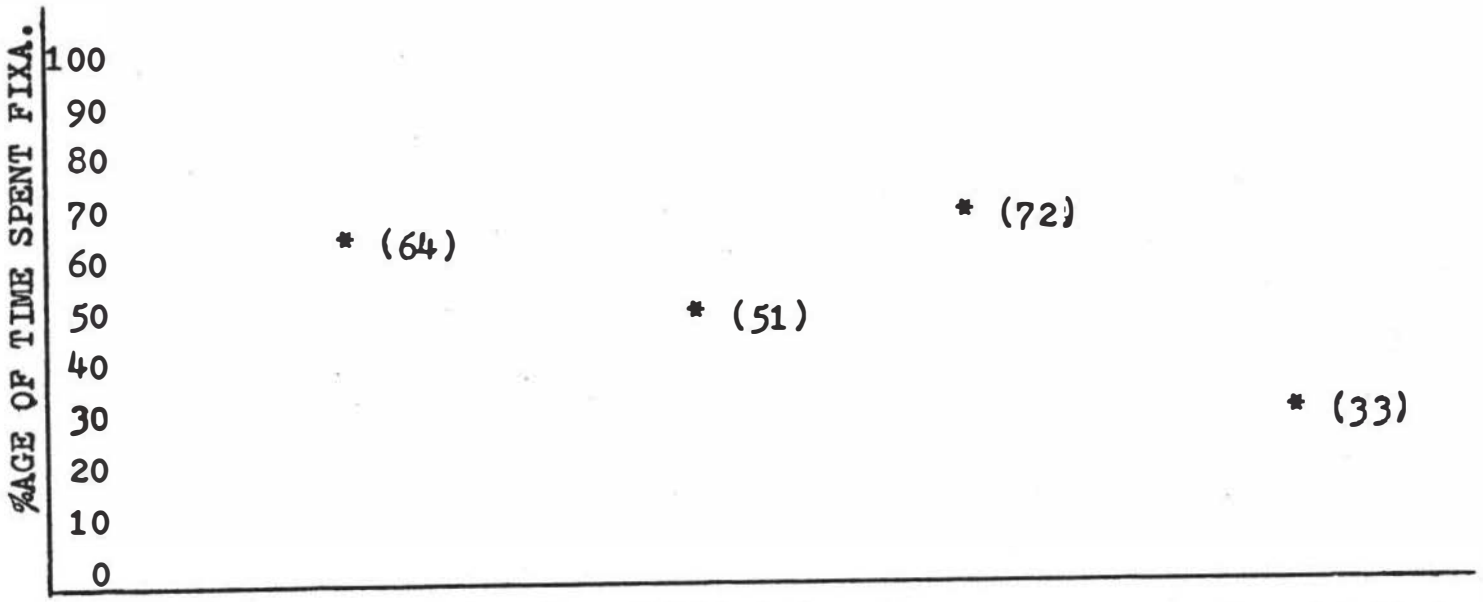

Figure 25. Percentage of Total Viewing Time for Subject 1.

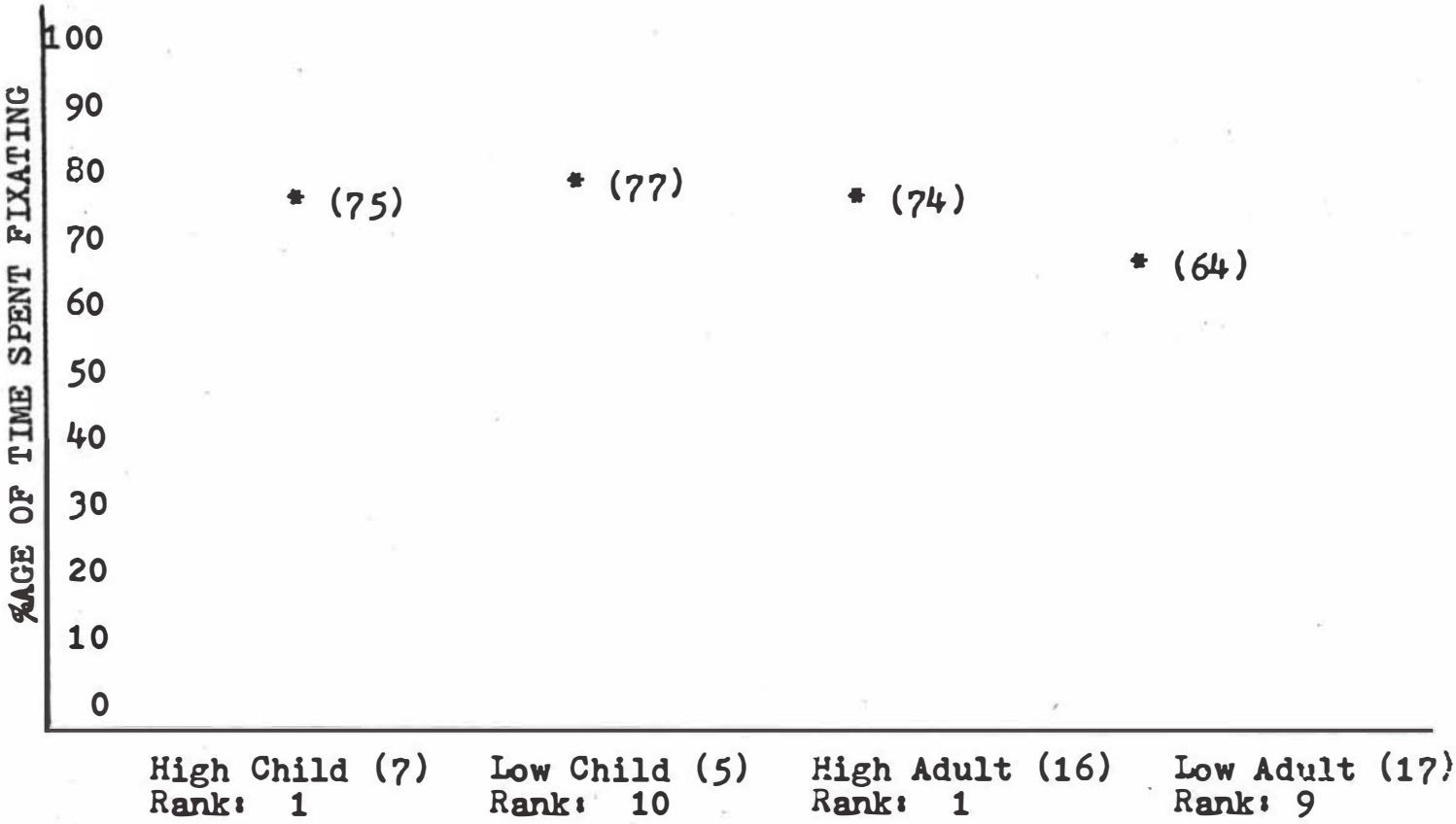

Figure 26. Percentage of Total Viewing Time for Subject 2.

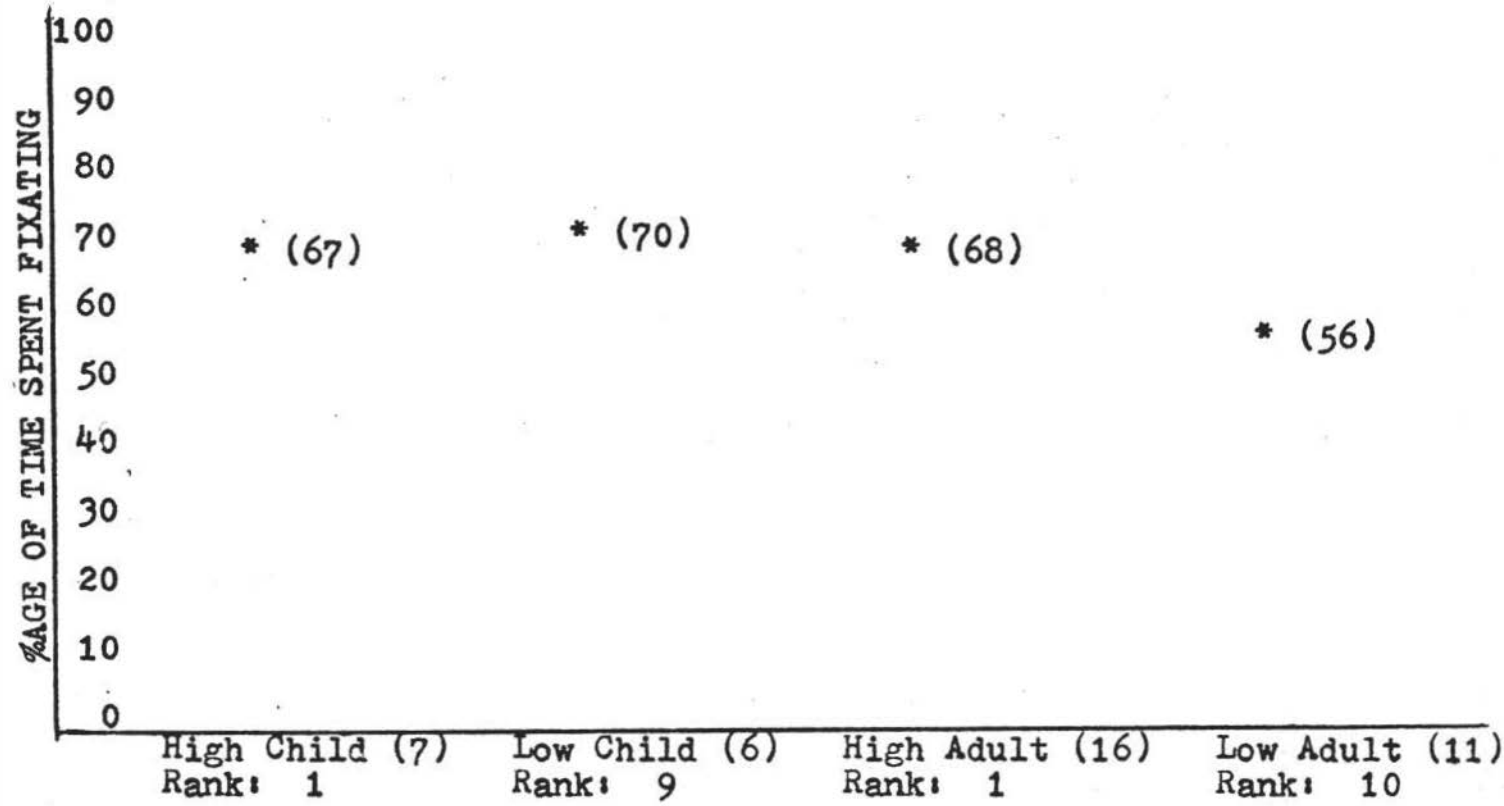

Figure 27. Percentage of Total Viewing Time for Subject 3.

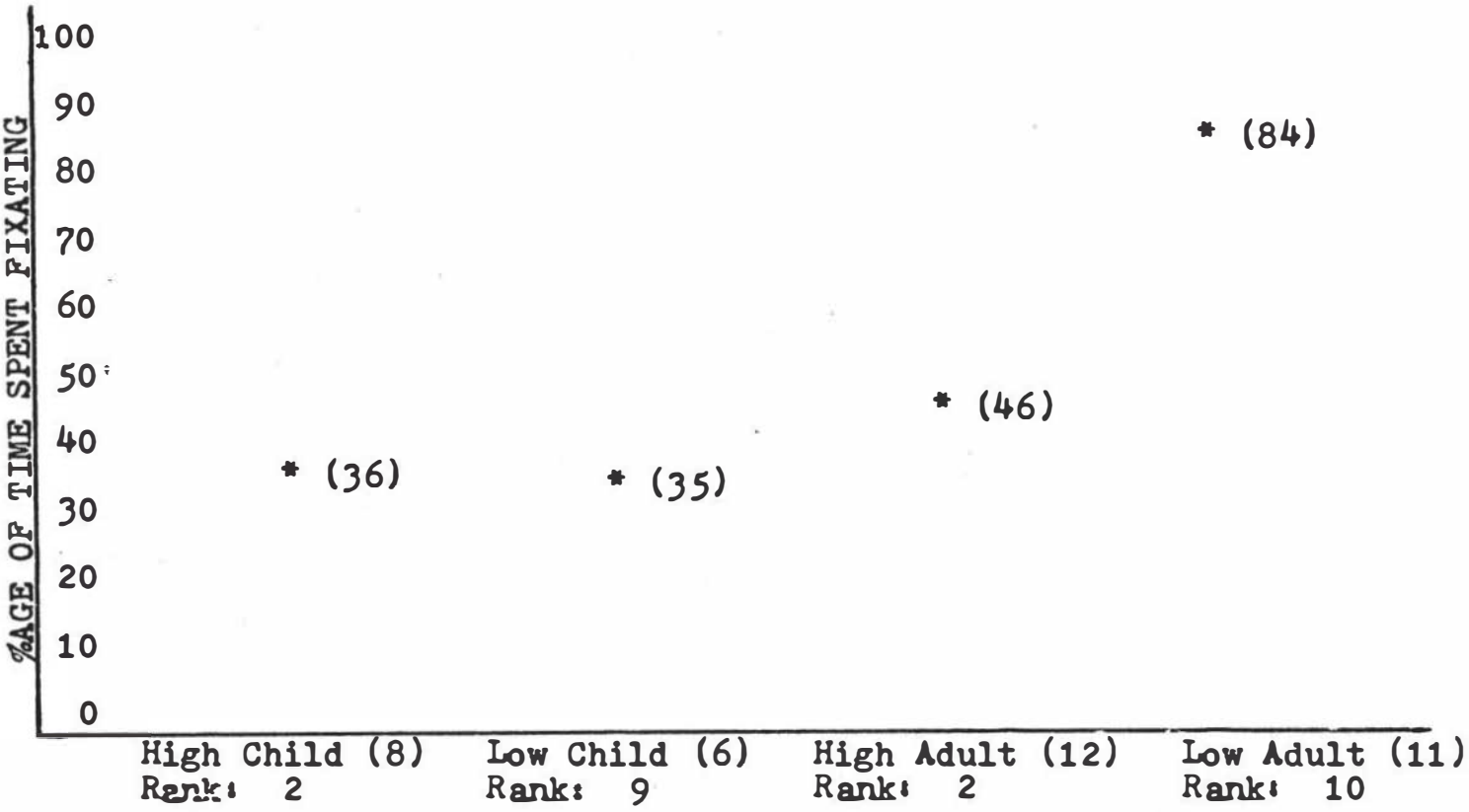

Figure 28. Percentage of Total Viewing Time for Subject 4.

Noton and Stark (1971) stated in their study with adults viewing stationary objects that approximately 10% of the total viewing time was spent in saccadic eye movements. In the present study the subjects spent much larger percentages of time scanning the picture sequences. It can be hypothesized that these children spent more time seeking information than adults normally do. It may be that adults are able to identify an object by a minimum amount of attention to features because of familiarity gained through experience. It can be assumed that children, lacking in experience, need to seek out meaningful features, thus a much larger amount of time is spent in scanning features. The percentages among the categories are too variable to hypothesize a relationship between category and percentage total viewing time spent fixating.

VIII. Discussion: Frequency and Duration of Fixation

The results of this study lend support to previous visual literacy research findings. For a long time investigators had thought that visual literacy is different for the child than it is for the adult. Previous research indicated that children spoke in longer and more complex language when talking about self-generated sequences than when talking about adult-generated sequences. It was found that adults agreed highly among themselves as to what constitutes a visually literate sequence but did not agree as highly with children. Conversely, children agreed highly among themselves as to what constituted a visually literate child-generated sequence but did not agree highly on what constituted a visually literate adult sequence. In this study the subjects consistently made more and longer fixations for child-generated sequences with high scale values than those with low scale values. This suggests that children value the same elements of picture sequences generated by other children to the same degree. The response in number and duration of fixation for adult-generated sequences was variable suggesting that elements in adult sequences did not carry the same value for these children.

Important implications for new educational materials are made. Presently the flow of visual images, particularly in reading readiness material, is one determined by an adult in response to an adult's perceptions. A child's cognitive development is based not on his choices but on an adult's. If an irrelevant cue is introduced discrimination learning is slowed (Lovejoy, 1968).

If a teacher cannot select relevant stimulus material for visual literacy training then the teaching-learning process becomes less effective than need be. This study suggests that children agree as to the relative amounts of information supplied by child-generated visual material but do not agree on adult-generated visual material. More time was spent fixating or obtaining information from child-generated sequences psychologically scaled as containing more visually literate material.

The term, information, as used here is somewhat different from common usage. Information, here, is directly related to the uncertainty of the presentation. Uncertainty would cause an individual to spend more time in order to determine the significance of the event. A visual of the theoretical model from which the statements on information come appears in Figure 29.

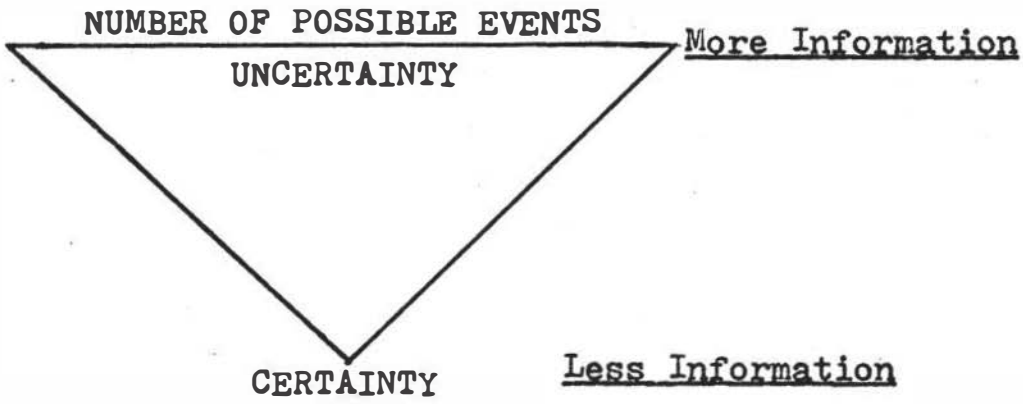

Figure 29. Theoretical Model of Information

The number of possible events in the case of frequency of fixation would be the number of fixations the child could possibly make in the time he viewed the sequence. It would be considered the absolute uncertainty if he had to make all the fixations in

order to determine the relevance of the sequence. At the same time he would be gaining the maximum amount of information. Absolute certainty would be one fixation meaning that a very minimum amount of information was needed to determine the relevance of the event. When speaking of relative amounts of information, then, it is the observed frequency of fixation relative to the number of fixations possible. The fact that the children agreed to the relative amounts of information supplied by child-generated visual material means that they agreed to the position of High Child and Low Child sequences in relation to the number of fixations possible. The tables below give the number of fixations and duration of fixations possible for the child-generated and adult-generated sequences viewed by each subject and the observed frequencies and duration.

Since it would require a minimum of two frames to be counted as a fixation and a minimum of one frame to allow for movement or refixation, the number of possible fixations was obtained by taking the number of frames each subject viewed the two sequences in each category and dividing by three. The possible duration was determined by taking the number of frames the subjects viewed each category and multiplying by .056 seconds assuming that a child could make on fixation for the entire time he viewed the sequence.

TABLE VI

RELATIVE AMOUNT OF INFORMATION FOR FREQUENCY OF FIXATION

Subject	Child # Possible	Child Observed High	Child Observed Low	Adult # Possible	Adult Observed High	Adult Observed Low
1	665	55	28	216	16	13
2	287	33	21	285	47	24
3	407	53	40	344	43	59
4	507	41	25	285	33	26

TABLE VII

RELATIVE AMOUNT OF INFORMATION FOR DURATION OF FIXATION (SECONDS)

Subject	Child # Possible	Child Observed High	Child Observed Low	Adult # Possible	Adult Observed High	Adult Observed Low
1	112.932	30.800	7.488	47.656	7.168	5.488
2	48.272	17.416	9.352	47.992	14.224	6.440
3	68.432	20.450	15.456	57.798	15.568	15.344
4	85.232	11.424	6.888	47.992	6.720	7.952

Information theory provides some interesting hypotheses to explain the differences between child- and adult-generated picture sequences on a child's visual perceptions. A system with little uncertainty has highly predictable states. These highly predictable states, therefore, are not very "informative" (Osgood and Sebeok, 1965). The fact that less information was obtained from the adult-generated sequences and low ranked child-generated sequences suggests that there was less uncertainty about their content. If the learning process is to be effective the child's curiosity must be aroused. Accounts of boredom in the classroom are commonplace.

IX. Scanning Patterns: Connection of Features

The saccades are the rapid jumps the eyes make as they scan the visual field. Fixation points serve to identify the features to which a person attends while the saccades serve to connect these fixation points. The connection of fixation points form a feature ring or the means by which a person identifies an object (Noton and Stark, 1971). The study of fixation points and the scanning patterns which connect these fixation points will identify the

features to which a child attends as he puts pictures together to tell a story.

The picture sequences were divided into sixteen equal parts and the placement of the point of fixation point is within one of these sixteen squares. Pieces of clear plastic were placed over the picture sequences. Fixation points were drawn on this plastic and interconnected in sequential order by lines.

The subjects in the present study tended to treat each picture in the picture sequence as individual entities. This would suggest that a sequence be considered as (x) number of parts rather than as a whole. The length in terms of number of pictures, however, was not an indicator of frequency of fixation nor of duration of fixation. That is to say that a sequence containing six pictures did not necessarily have an increase in frequency of fixation or duration of fixation over a two picture sequence simply because it had more pictures. In fact the three picture sequence received the most number of fixations although three of the eight sequences contained more pictures. For this reason, the sequences were considered as wholes for determining the frequency and duration of fixation. The breakdown for frequency and duration of fixation of the sequences into their component parts is outlined in Appendix A.

The sequences were arranged such that the story progresses from left to right. In only two cases did a subject begin with the picture farthest to the left and progress to the right. Three subjects in viewing the five and six picture sequences started on middle picture (either third or fourth picture) and progressed to

the left and then to the right. One subject started with a middle picture and then progressed right then left. All subjects had left to right and right to left eye movements suggesting that these subjects had not been trained in the left to right movements taught to young children in reading. This is not to suggest that a right to left or even mixed pattern is preferable to the left to right pattern since neither directional pattern dominated in terms of number.

This investigation supports previous studies (Guba and Wolf, 1964; Thomas, 1968; Schissler, 1967; and Noton and Stark, 1971) which concluded that scanning patterns are highly individualistic behaviors. No two subjects followed the same general pattern nor, generally speaking, connected the same features together. One subject's scanning pattern appeared to be totally random, crisscrossing the pictures in no preferred order. One subject generally fixated on a feature, viewed two other features and then returned to the original feature forming triangular patterns over the picture sequences. One subject's pattern was similar but usually viewed three but no more than four other features forming square or pentagonal patterns over the sequences. One subject usually considered only two features before moving on to another set of features. These subjects used the same patterns throughout the experiment. The subjects in the Noton and Stark study (1971) also maintained their same pattern throughout the experiment. It should be emphasized here that the subjects maintained their typical scanning patterns regardless of which sequences, adult-generated or child-generated, they saw. The patterns, however, followed no consistent

direction suggesting that scanning patterns are not habitual eye movements. The following figures are examples of each subject's scanning pattern.

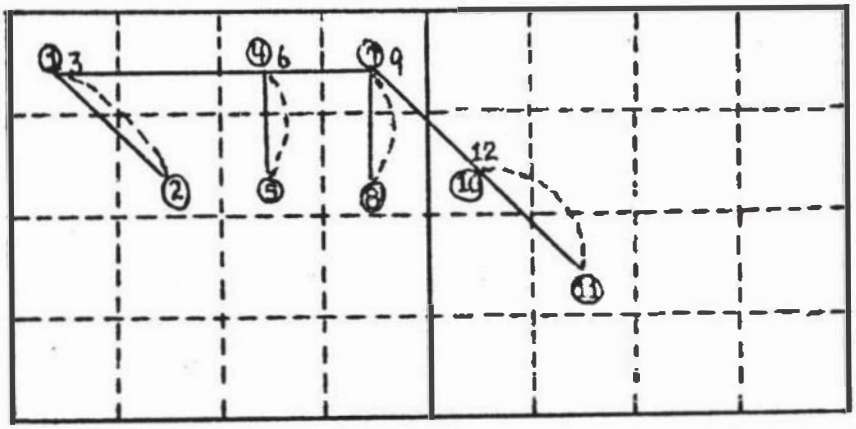

Figure 30. Scanning Pattern for Subject 1.

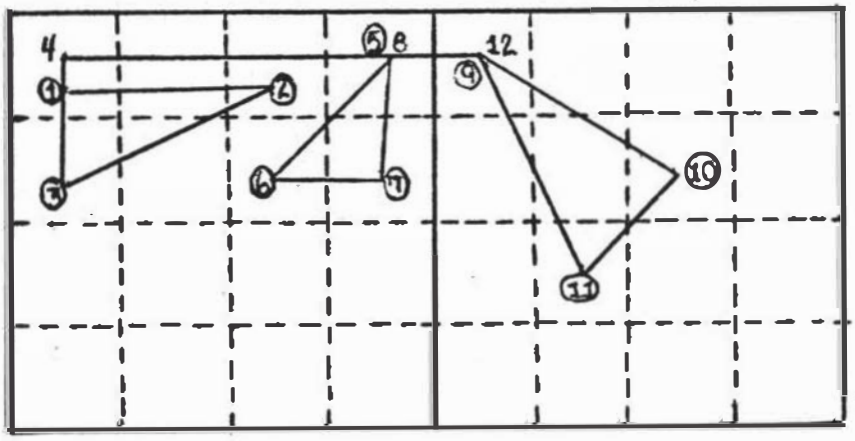

Figure 31. Scanning Pattern for Subject 2.

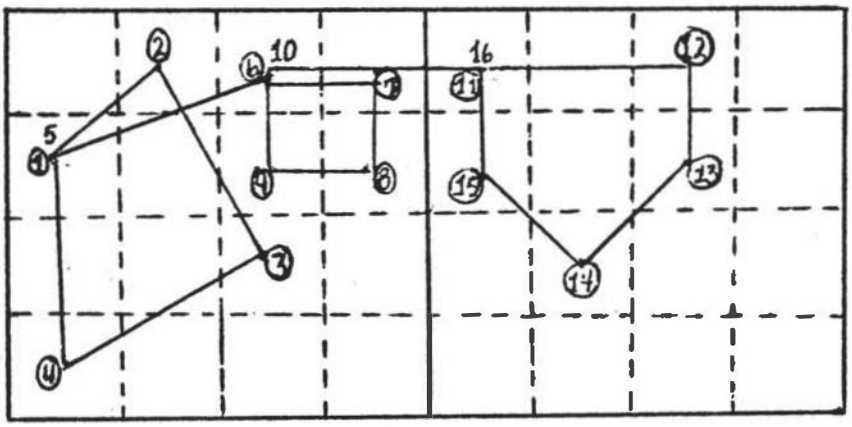

Figure 32. Scanning Pattern for Subject 3.

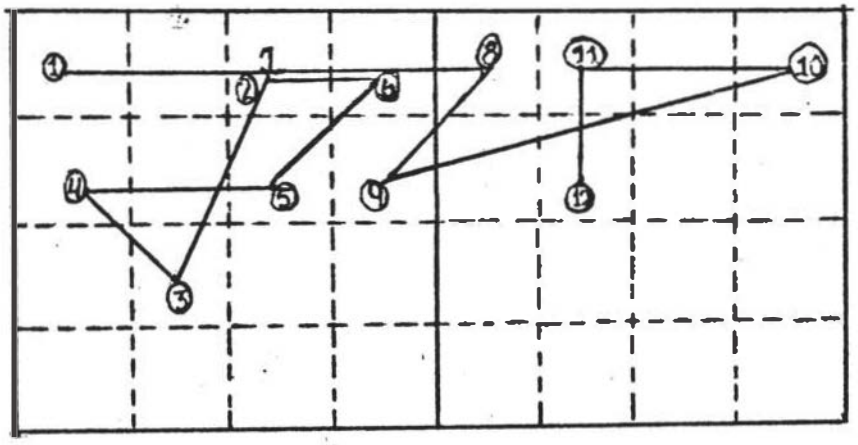

Figure 33. Scanning Pattern for Subject 4.

Except for three of the sixteen presentations of the picture sequences the subjects considered only small portions of each picture. Of these three, one sequence was adult-generated (sequence number eleven) and two were child-generated (sequence numbers five and six). All of these sequences received low psychological scale values. Because more features were attended to did not necessarily mean a noticeable increase in the number of

fixations. This was true only of the adult-generated sequence which received fifty-nine fixations. Most of the features in these sequences were fixated only once then ignored by the child. This finding also suggests that there is much excess in present visual displays. One subject completely ignored one picture in a three picture sequence and fixated one picture of a two picture sequence only once. This excess may be necessary to put the features into perspective for the adult but is apparently unneeded by the child.

Each picture was generally considered individually with the subjects fixating a single picture a few times; then they would go on to another picture for several fixations and return to the first picture or move on to a completely different picture. Toward the end of the presentations two subjects scanned as many as five pictures perhaps in an attempt to connect the pictures into a sequence although their language samples did not indicate this.

Except for one presentation of sequence eleven and one of sequence number twelve the subjects fixated only one or two points on an object in the adult-generated sequence. One may hypothesize from information theory that these objects had highly predictable states needing only one or two features for identification. Having these highly predictable states they were less informative resulting in the general lower psychological scale values for adult-generated sequences.

When movement was from one picture to another, the features connected were often totally dissimilar probably due to the fact

that the pictures were considered separately. For example, in sequence number six, a door was visually connected to the leg of the woman in the next picture. One child did connect like objects in sequence number seven. For example the same girl was fixated in three successive feature changes, then the other girl was visually traced throughout the sequence. The doll in one picture was connected to the doll in another and the window in one picture was connected to the window in another. Except for this one case, the subjects appeared to identify objects rather than sequence them. This was true both visually and verbally. In telling a story, the subjects listed the objects present rather than telling a story about them. Visually they connected (x) number of features which were usually on only one or two objects suggesting an identification process.

The subjects visually outlined objects suggesting that shape is the feature attended to for identification. Size and color appeared to play an insigificant role. A great majority of the fixations were on people's faces. Following information theory, facial features are novel, less predictable than many things and, therefore, highly informative. On the child-generated sequences many fixations were on background objects, corners of rooms and darkened portions of the pictures. It appears that such things are unpredictable in terms of identification and therefore informative.

As can be seen from Figures 30 through 33, subjects 1, 2, and 3 followed a consistently ordered pattern while viewing the sequences. No order is displayed by subject number 4's scanning

strategy. This subject was highly distractible during the testing situation. Much of her time was spent looking in the mirror and around the testing room. On one three picture sequence she made no fixations on one picture and fixated one picture of a two picture sequence only once. This would indicate a disinterest in the task. It is assumed, then, that the distractibility of this subject resulted in no orderly form of scanning behavior.

In summary this study supports the view that scanning patterns are highly individualistic behaviors. The subjects used the same general pattern throughout the experiment. Both left to right and right to left patterns were observed. The subjects considered each picture separately and generally considered only small portions of the pictures. The subjects tended to identify the objects in the pictures rather than sequence the pictures into a story. The objects of the adult-generated sequences are highly predictable in terms of identification and, therefore, are less informative. The feature attended to for identification is shape. Facial features and obscure objects such as corners of rooms, background objects and darkened portions of pictures had informative value. One subject visually sequenced the pictures by matching like objects.

X. Relationship of Physiological Measures to Scale Values

Frequency of Fixations.-- As stated previously a close relationship exists between number of fixations and the psychological scale values attached to child-generated picture sequences. The subjects consistently had an increase in frequency of fixation

for the child sequences with high ranked scale values. All subjects made fewer fixations for child sequences with low scale values. No consistent relationship exists between frequency of fixation and the psychological scale values of the adult-generated sequences. Two subjects made more fixations of the adult sequences with high scale values and two made more fixations on the adult sequences with low scale values.

Duration of Fixation.-- A close relationship exists between the duration of fixation and the psychological scale values of child-generated sequences. All the subjects spent longer periods of time fixating the child sequences with high scale values than they did fixating the child sequences with low scale values. No consistent relationship existed between duration of fixation and the psychological scale values of adult-generated picture sequences. Three subjects spent more time fixating the adult sequences with high scale values and one spent more time fixating the low ranked adult-generated sequence.

These findings support those of Kingery (1972), i.e. children agree highly among themselves as to what constitutes a visually literate child-generated sequence but do not agree as highly as to what constitutes a visually literate adult-generated sequence. The subjects in the present study agree as to the relative amount of information to be obtained from child-generated sequences. The informative value of adult-generated visual material varied among the subjects.

CHAPTER V

Summary and Conclusions

The eyes are the most active of all human sense organs. They are in constant motion as they scan and inspect details of a visual world. It has been shown that movements of the eye play an important role in visual perception (Noton and Stark, 1971; Thomas, 1968; Gould and Shaffer, 1965). It is widely accepted that nearly all visual perception occurs during the fixation of the eyes. More perception time could take the form of more fixations or longer fixations or both (Fleming, 1969). It is assumed that a person will look at the parts of a picture that hold for him the most information. Analysis of the order of fixation suggests a format for the interconnection of features (Noton and Stark, 1971). This investigation is a logical sequel to past research attempting to measure the impact of visuals on children and to identify meaningful and non-meaningful features of these visuals. The frequency of fixations, duration of fixations and the study of scanning patterns are the physiological measures necessary in determining the meaningful and non-meaningful features to which a child attends when putting pictures together to tell a story.

The purpose of this investigation was to determine the physiological measurements of a child's eye movements in relation

to attending to visual stimuli as he views adult-generated and child-generated picture sequences. A second purpose of this investigation was to analyze the relationship of these physiological measurements to the psychological scale values attached to the picture sequences. In view of the stated purposes six questions were posed at the onset of this investigation:

1. What is the number of eye fixations a child makes when viewing a child-generated picture sequence?

2. What is the number of eye fixations a child makes when viewing an adult-generated picture sequence?

3. What is the amount of time spent by a child viewing a child-generated picture sequence?

4. What is the amount of time spent by a child viewing an adult-generated sequence?

5. To what features does a child attend when viewing a picture sequence?

6. What is the relationship of physiological measurements to the psychologically scaled values attached to the picture sequences?

The review of literature was three-fold. A discussion of learning and in particular cue attention resulted in the conclusion that a child attends to cues in the environment which carry relevant information for him and that introduction of irrelevant cues slows discrimination learning. Consideration was given to methodological means of obtaining physiological measurements of a child's eye movements. Four major techniques were analyzed and

it was concluded that direct photography offered the best means of obtaining measurements without introducing numerous variables which could not be accounted for in the results. A review of previous visual literacy research resulted in the following generalizations:

1. Children use longer and grammatically more complex language when talking about self-generated sequences than when talking about adult-generated picture sequences.

2. Visual literacy training significantly increases the length and complexity of children's language responses.

3. Adults agree highly with other adults as to what constitutes a visually literate picture sequence but not so highly with children.

4. Children agree highly with other children as to what constitutes a visually literate picture sequence but not so highly with adults.

The following procedures were employed to carry out the stated purposes of this investigation:

1. Eight picture sequences were centered and mounted on four by twenty-two inch stimulus cards. These eight sequences were chosen from the Kingery (1972) study. In the Kingery study ten adult-generated and ten child-generated picture sequences were rank ordered by children according to the psychological scaling methodology of paired comparisons. Those sequences which ranked the two highest and the two lowest in each of the two categories, adult-generated and child-generated, comprised the eight sequences.

2. These sequences were attached to a mirror by strings

which allowed them to be raised and lowered on the mirror surface. Two twenty-four by thirty inch mirrors were employed. One to which the sequences had been attached had horizontal and vertical lines drawn on it to help the examiner determine eye movement. The other mirror in a larger stand was placed above and behind the subject and picked up the image in the lower mirror of the child viewing the picture sequences. This allowed the image to be reflected away from the child so that a camera positioned out of the child's sight could record the image.

3. A Bolex 155 camera was positioned in reference to the upper mirror so as to allow optimum view of the child's eyes. The image was recorded on Kodak Super 8 Movie Film. The film was shot at a speed of 18 frames per second. Each frame, therefore, accounted for .056 seconds of time.

4. Four subjects between the ages of four years, six months and four years, eleven months viewed the picture sequences and talked about them.

5. A frame by frame analysis was made employing the following physiological measures: frequency of fixation, duration of fixation, and scanning patterns.

The results generated the following conclusions:

1. All four subjects made more and longer fixations on the child-generated sequences with high psychological scaled values than they did on those with lower scale values. This supports previous findings that children agree among themselves as to what constitutes a visually literate child-generated picture sequence.

2. Psychological scale values were no indicator of the

frequency and duration of fixation on adult-generated sequences. This also supports previous findings that children do not agree among themselves as to what constitutes a visually literate adult-generated picture sequence.

3. The subjects spent more time viewing high ranked child-generated sequences than they did viewing the other sequences. This suggests that these child-generated sequences had highly unpredictable states and, therefore, were more informative than the adult-generated sequences.

4. Scanning patterns are highly individualistic behaviors. The subjects, however, maintained their same general scanning pattern throughout the experiment.

5. The subjects considered each picture of the picture sequence as an individual entity suggesting an identification rather than a sequencing process.

6. The subjects considered only one or two features of an object in the adult-generated sequences. This suggests that these objects were easily identifiable and, therefore, carried less informative value.

7. The subjects visually outlined objects suggesting that shape is the feature attended to when identifying an object.

8. Facial features and obscure features such as corners, background objects and darkened portions of the picture received many fixations suggesting that the uncertainty of their identification made them more informative.

9. Three of the subjects in this investigation exhibited an orderly form of behavior while scanning the picture sequences.

A highly distractible child may not exhibit the same orderliness of behavior although the same task is completed.

10. A close relationship exists between frequency of fixation for child-generated picture sequence and the ranked psychological scale values attached to those picture sequences.

11. No apparent relationship exists between frequency of fixation and duration of fixation for adult-generated sequences and the ranked psychological scale values attached to those picture sequences.

Implications for Future Research

That visuals have an important impact on a child's learning is becoming more and more evident. Conclusions drawn from this study and previous visual literacy research have indicated that visual literacy is quite different for the child than it is for the adult. This perceptual mismatch indicates a strong need to change present educational materials generated by adults to more meaningful aides for optimum learning by the child. The parameters of picture sequencing by children still present a vague and much needed area for visual literacy research.

The specific needs for future research generated by this investigation appear evident:

1. The effect of sequence length on a child's physiological and psychological response to visual materials needs to be assessed. As a group, sequences with high scale values tended to be longer but there was much within-group variability. A study with a systematic change in sequence length with appropriate measures

taken is strongly indicated. It would appear logical that a child would make more fixations as the length of the picture sequence increased simply because there is more to see.

2. Results from this study indicate that a child goes through an identification rather than a sequencing process when putting pictures together to tell a story. Other studies have have shown that a child's language complexity increases when he is trained in picture sequencing (Strandberg and Griffith, 1969) or is not confined to the pictures and is allowed to use his power of abstraction (Brent and Katz, 1968). A study employing a detailed language analysis is indicated to determine what differences in language structure exist before and after training in visual sequencing both with and without the child's being confined to pictures. Physiological measures should then be assessed. It may be that the features a child attends to when looking at pictures for identification (before training) may be quite different from those he attends to when he is actually putting the pictures together to tell a story.

APPENDIX

APPENDIX

Frequency of Fixation.-- The following figures give the number of fixations made by each subject on the individual pictures of the picturo sequences they viewed.

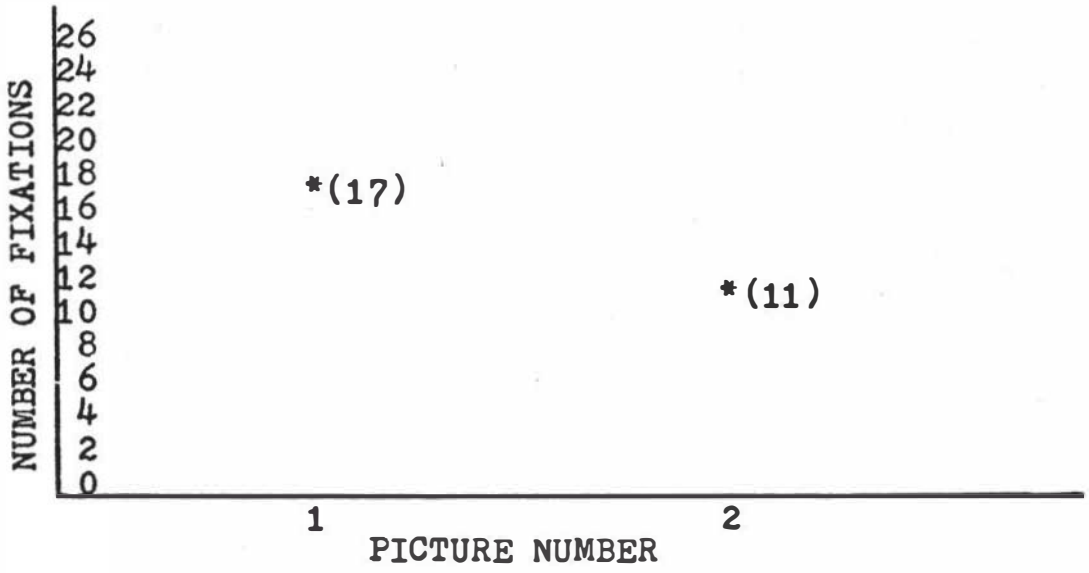

Figure A-1. Sequence 5 (Low Child) for Subject 1.

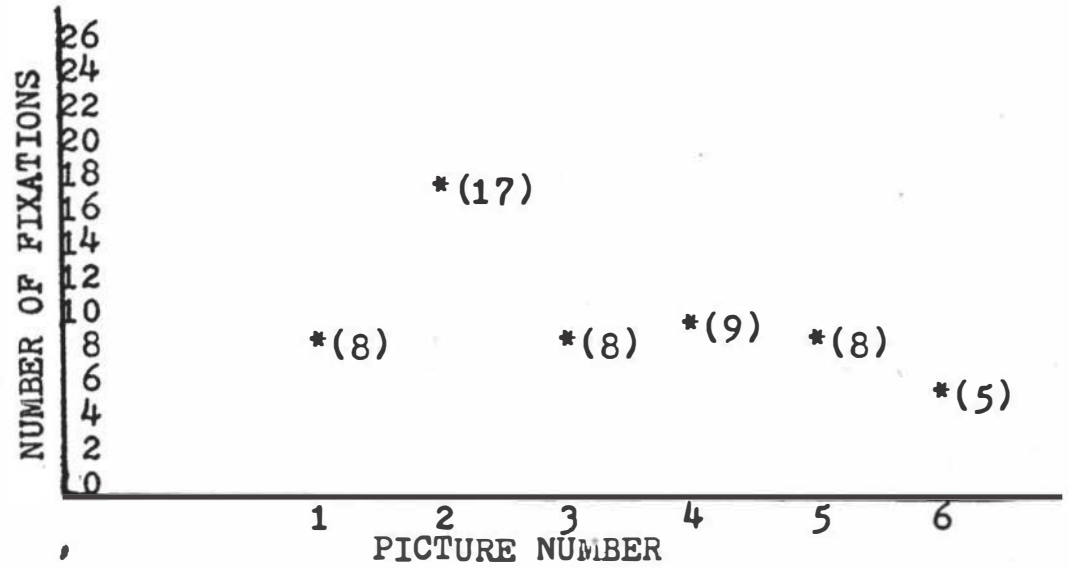

Figure A-2. Sequence 8 (High Child) for Subject 1.

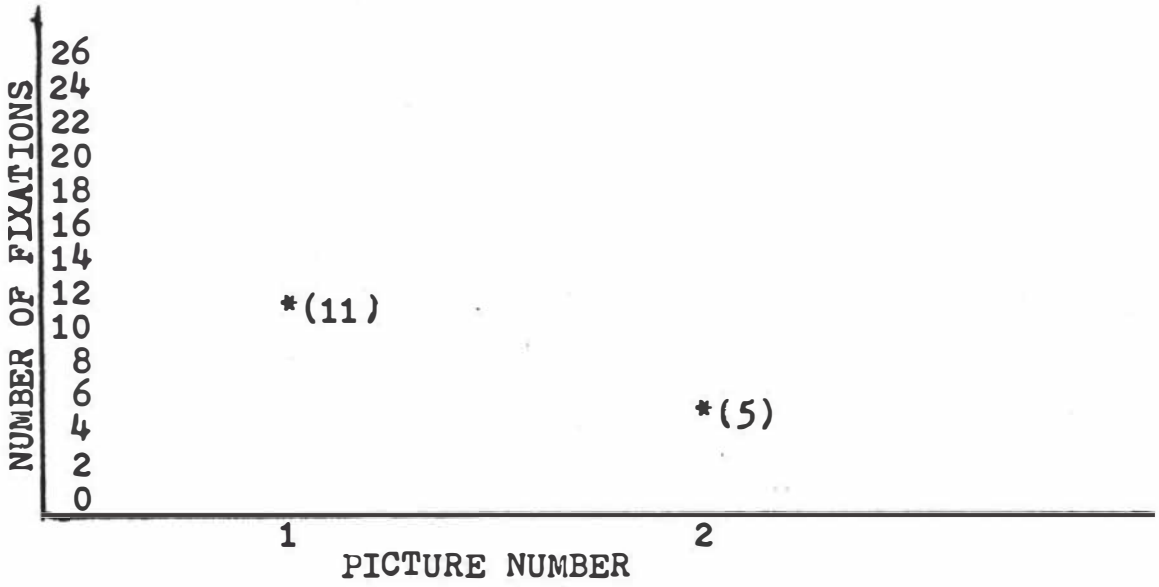

Figure A-3. Sequence 12 (High Adult) for Subject 1.

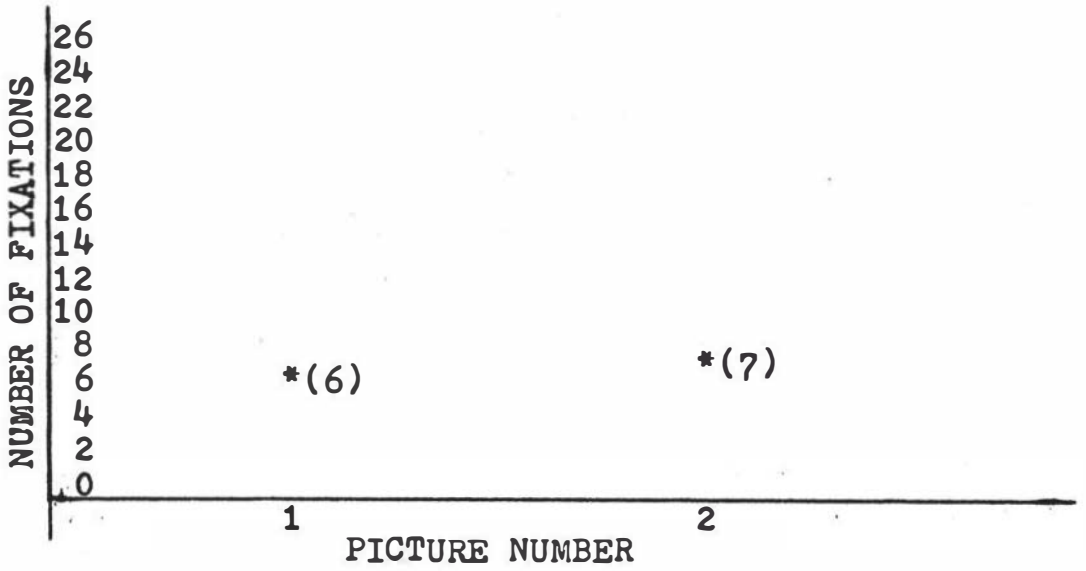

Figure A-4. Sequence 17 (Low Adult) for Subject 1.

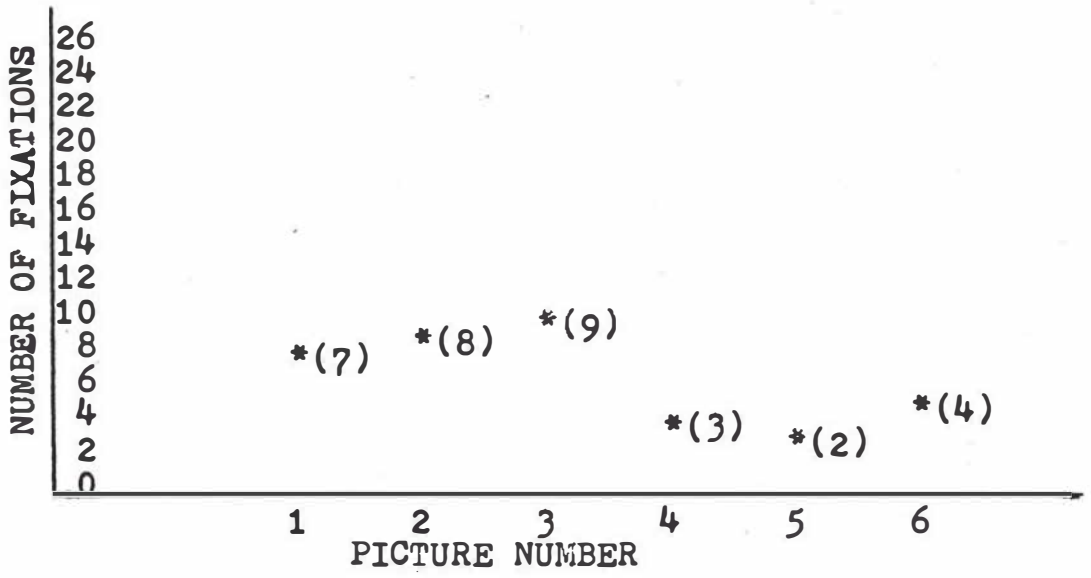

Figure A-5. Sequence 7 (High Child) for Subject 2.

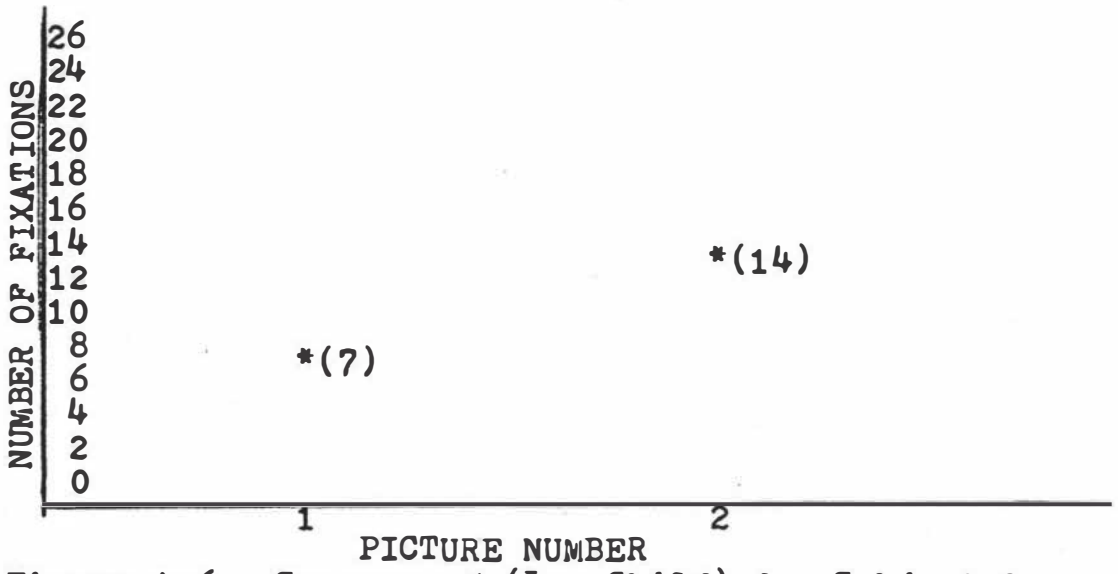

Figure A-6. Sequence 5 (Low Child) for Subject 2.

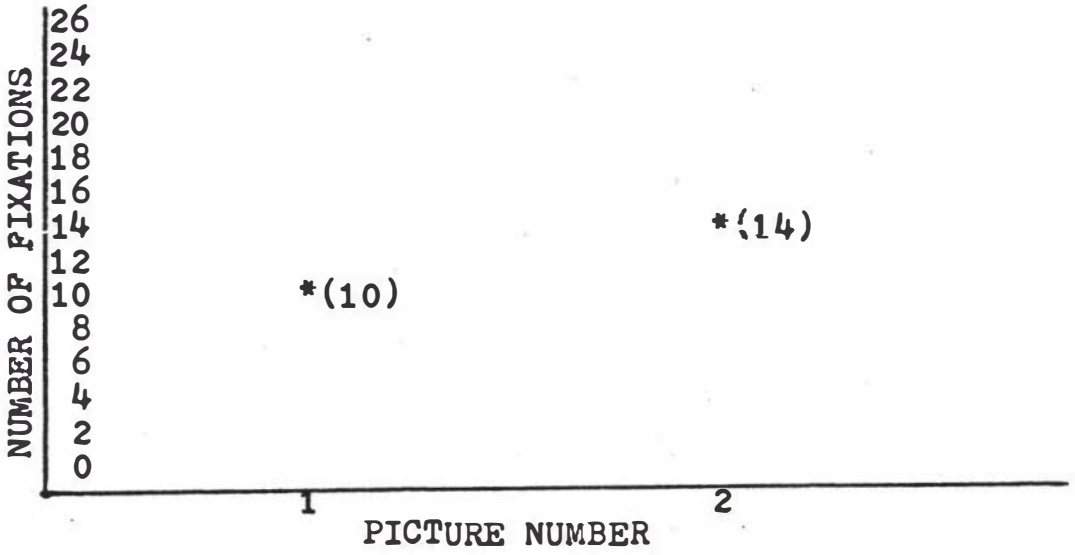

Figure A-7. Sequence 17 (Low Adult) for Subject 2.

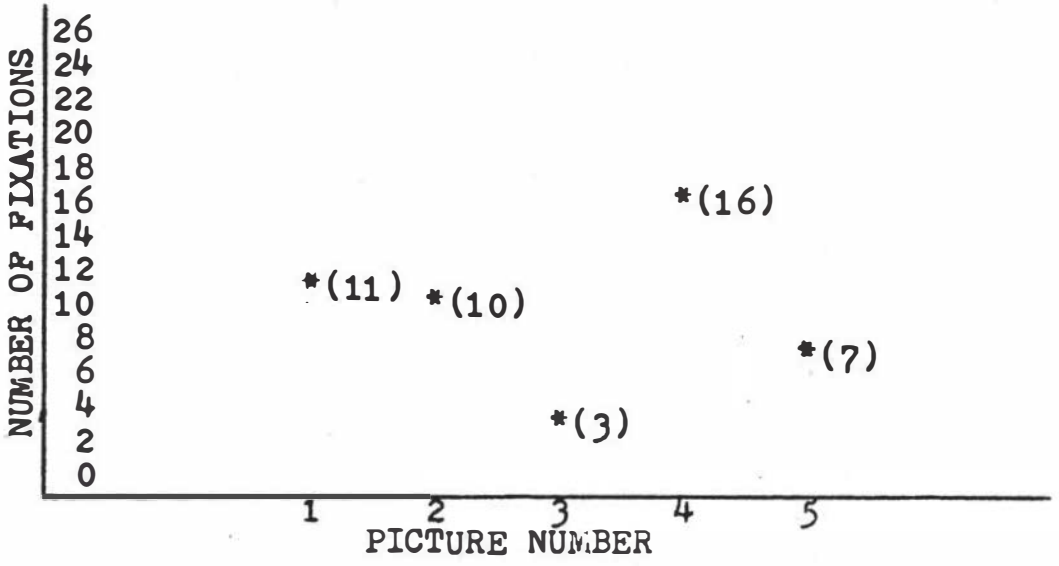

Figure A-8. Sequence 16 (High Adult) for Subject 2.

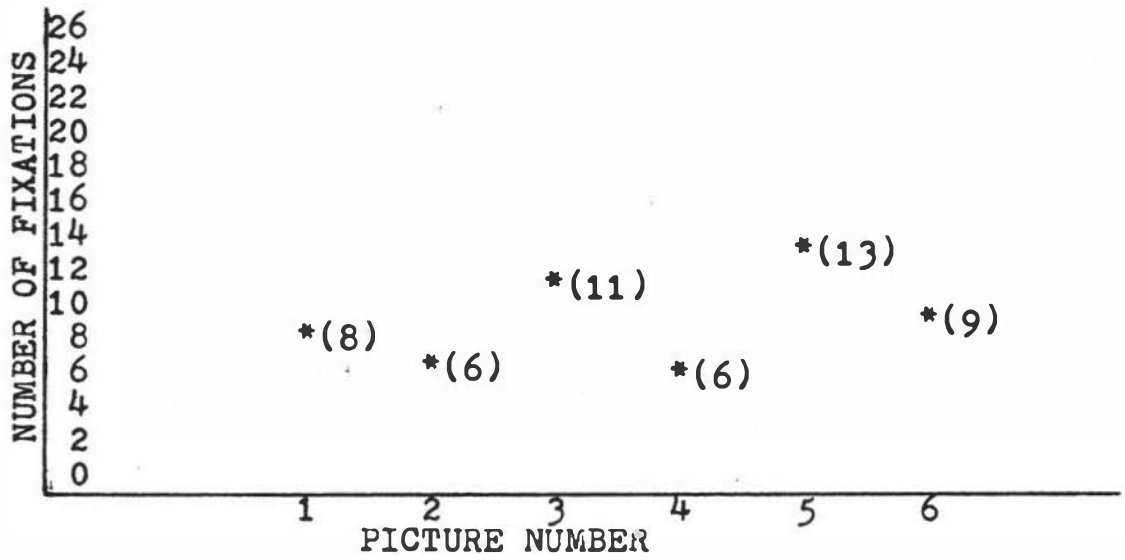

Figure A-9. Sequence 7 (High Child) for Subject 3.

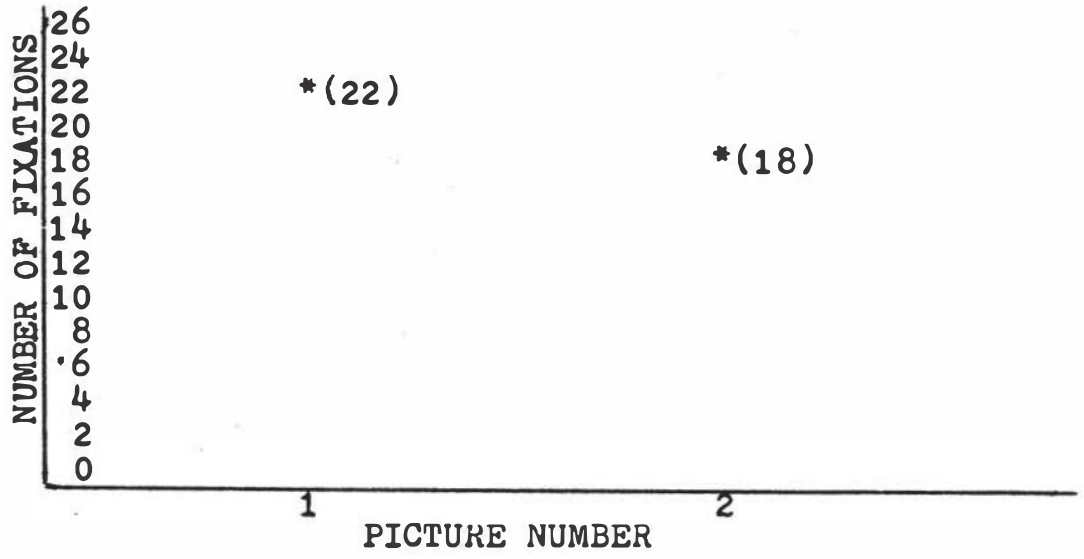

Figure A-10. Sequence 6 (Low Child) for Subject 3.

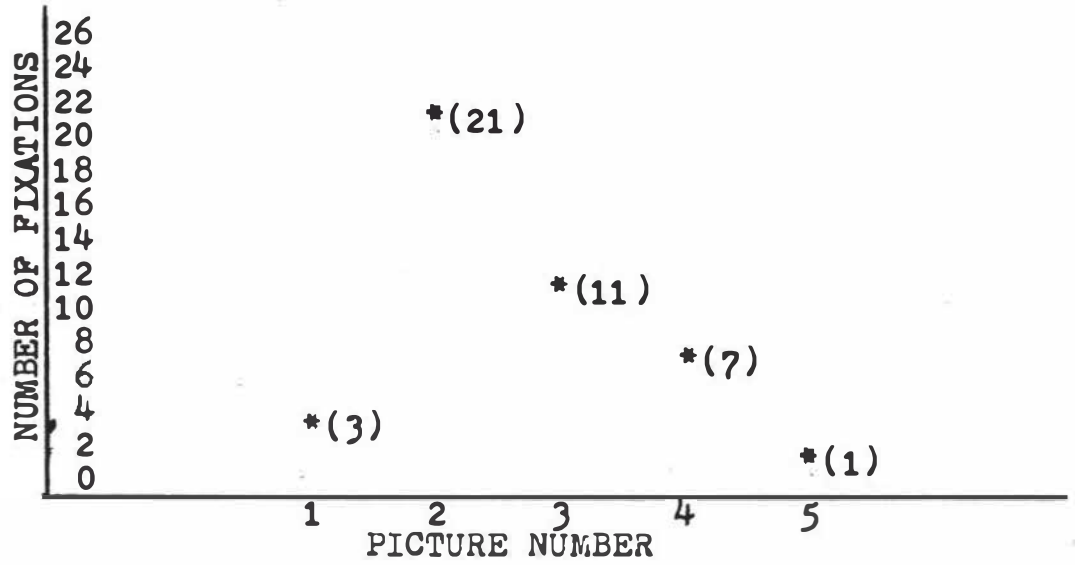

Figure A-11. Sequence 16 (High Adult) for Subject 3.

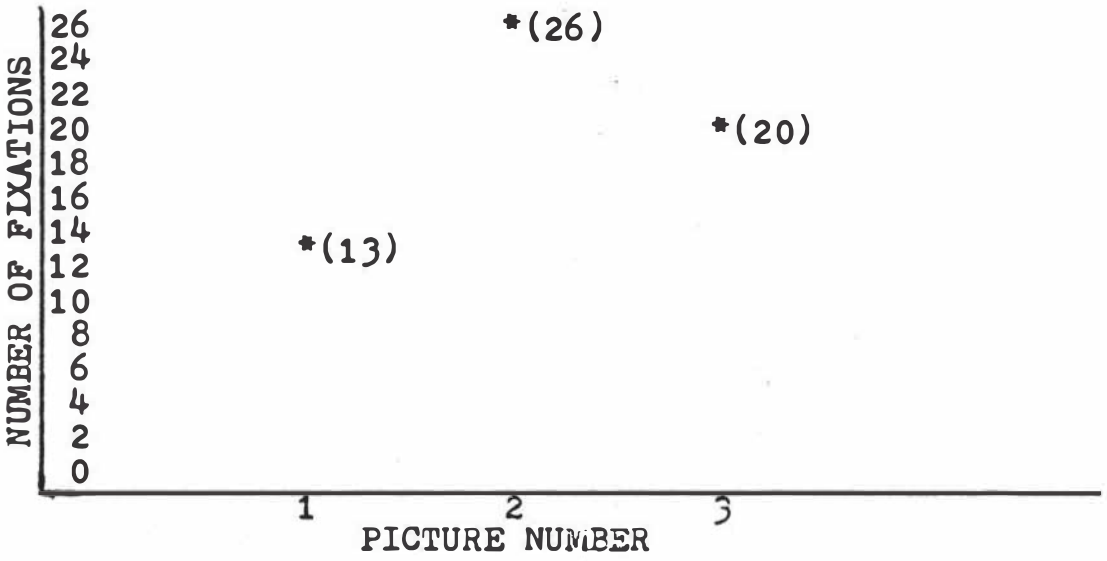

Figure A-12. Sequence 11 (Low Adult) for Subject 3.

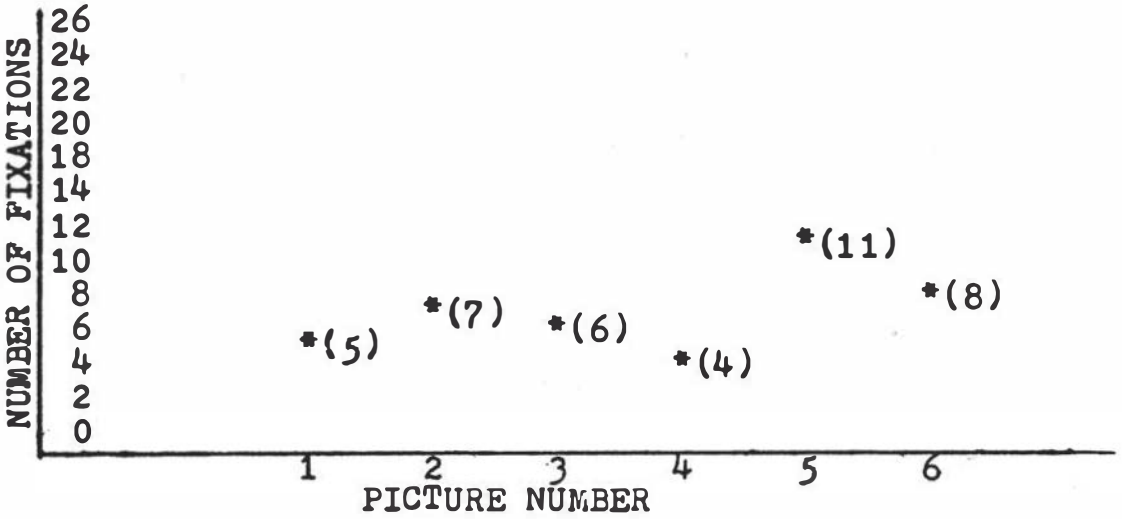

Figure A-13. Sequence 8 (High Child) for Subject 4.

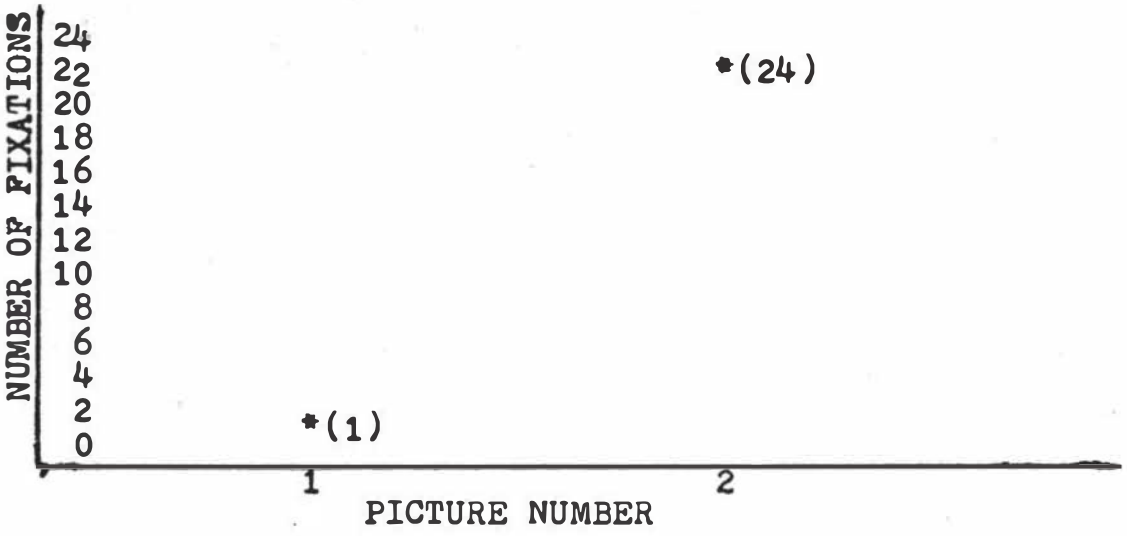

Figure A-14. Sequence 6 (Low Child) for Subject 4.

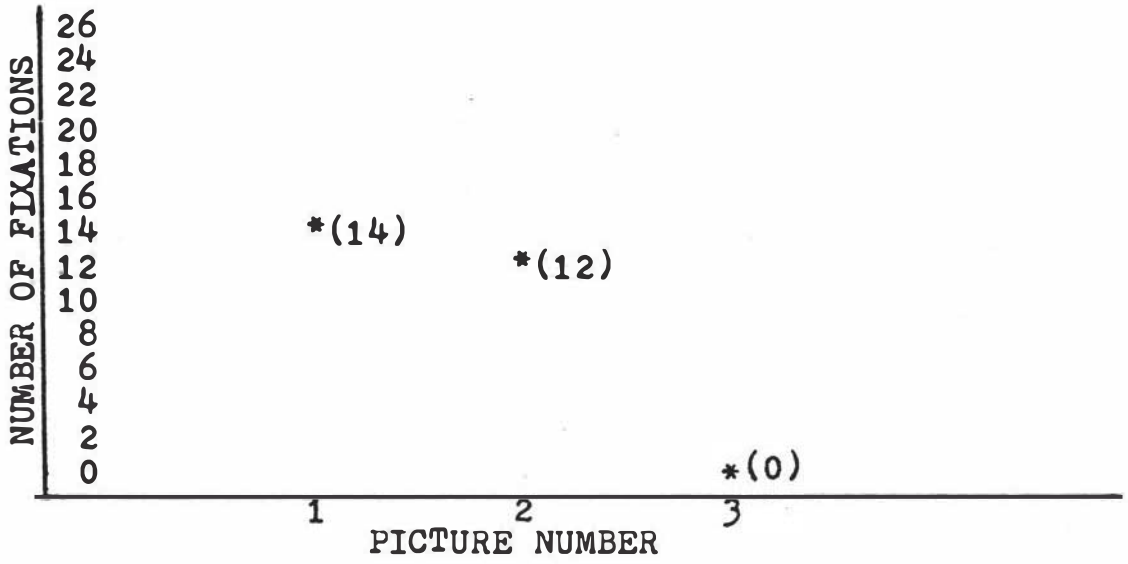

Figure A-15. Sequence 11 (Low Adult) for Subject 4.

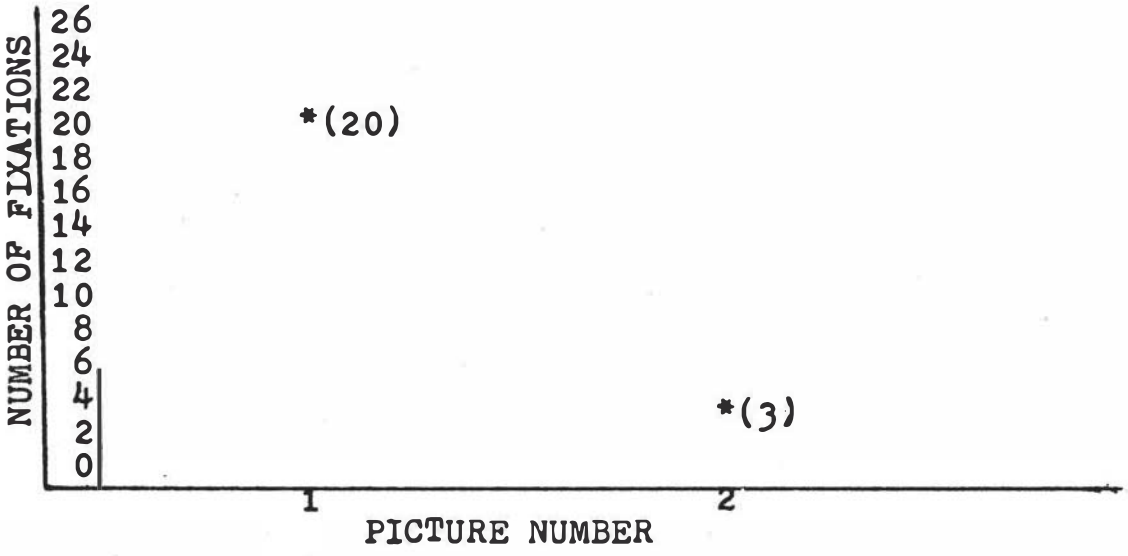

Figure A-16. Sequence 12 (High Adult) for Subject 4.

Duration of Fixation.-- The following figures give the duration of fixation made by each subject on the individual pictures of each picture sequence they viewed. The duration of fixation is represented in seconds.

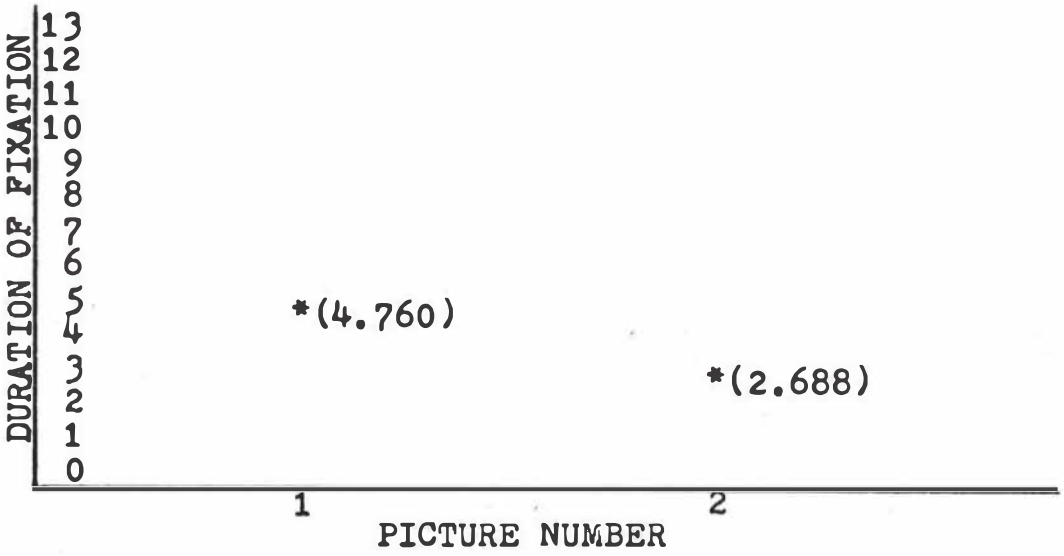

Figure A-17. Sequence 5 (Low Child) for Subject 1.

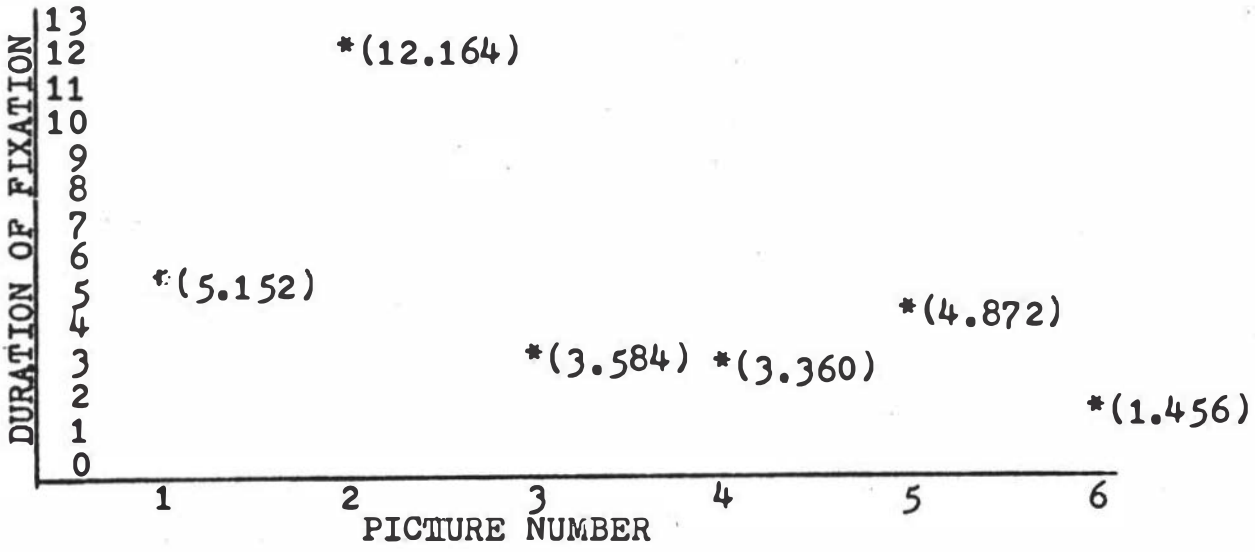

Figure A-18. Sequence 8 (High Child) for Subject 1.

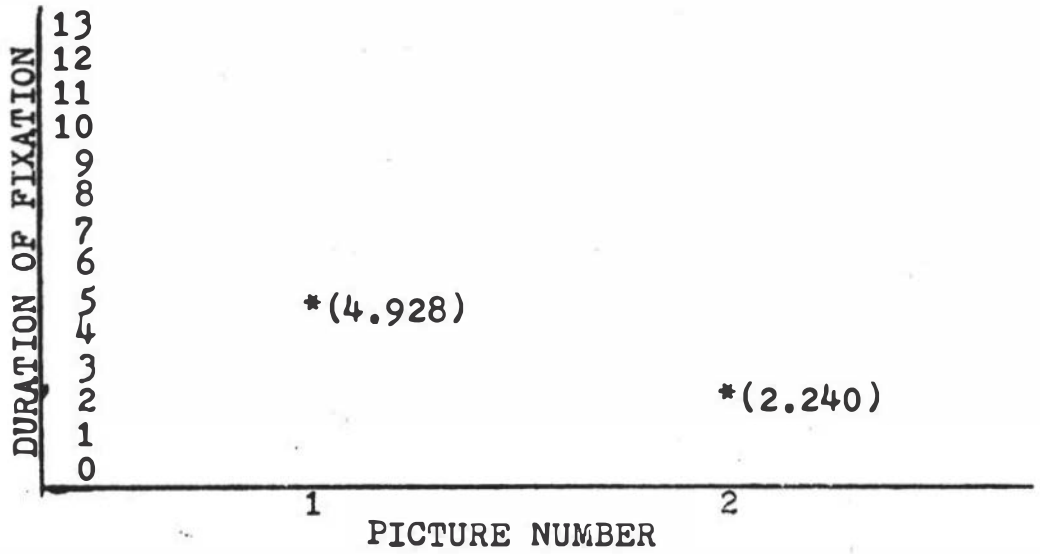

Figure A-19. Sequence 12 (High Adult) for Subject 1.

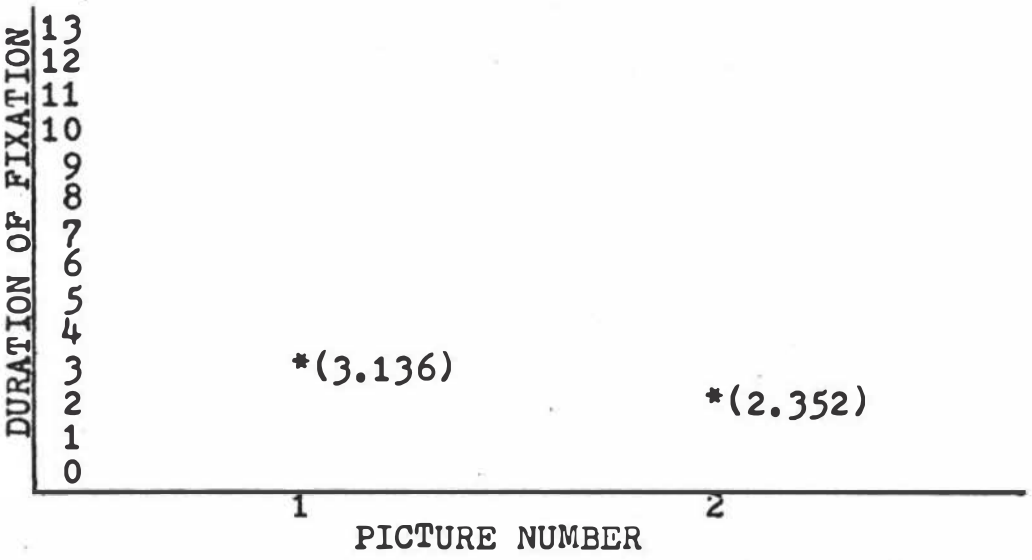

Figure A-20. Sequence 17 (Low Adult) for Subject 1.

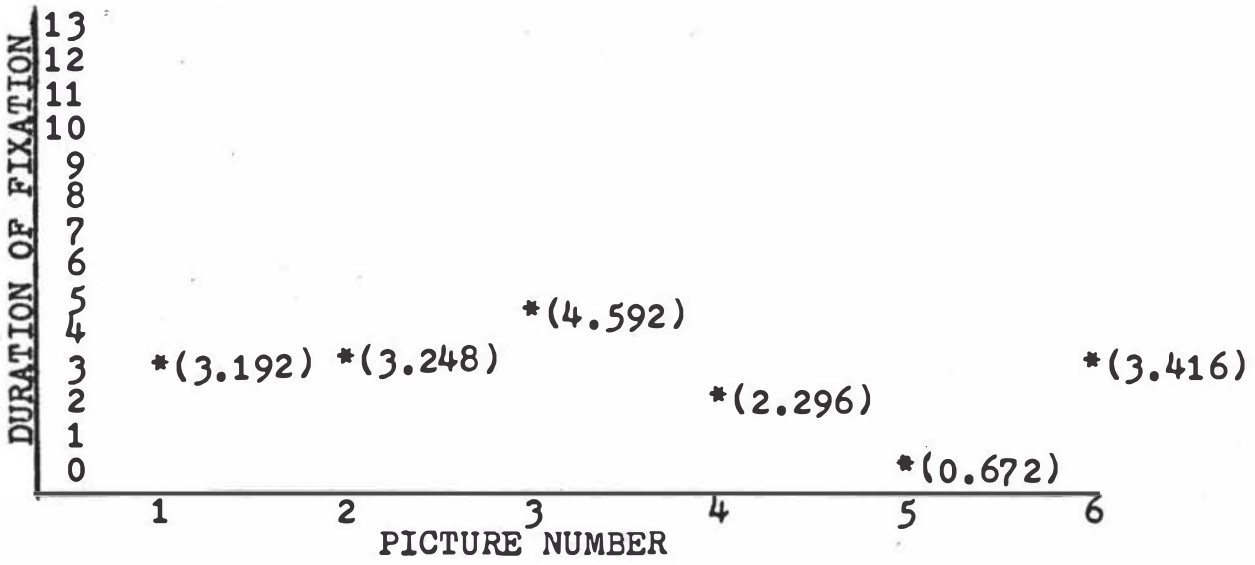

Figure A-21. Sequence 7 (High Child) for Subject 2.

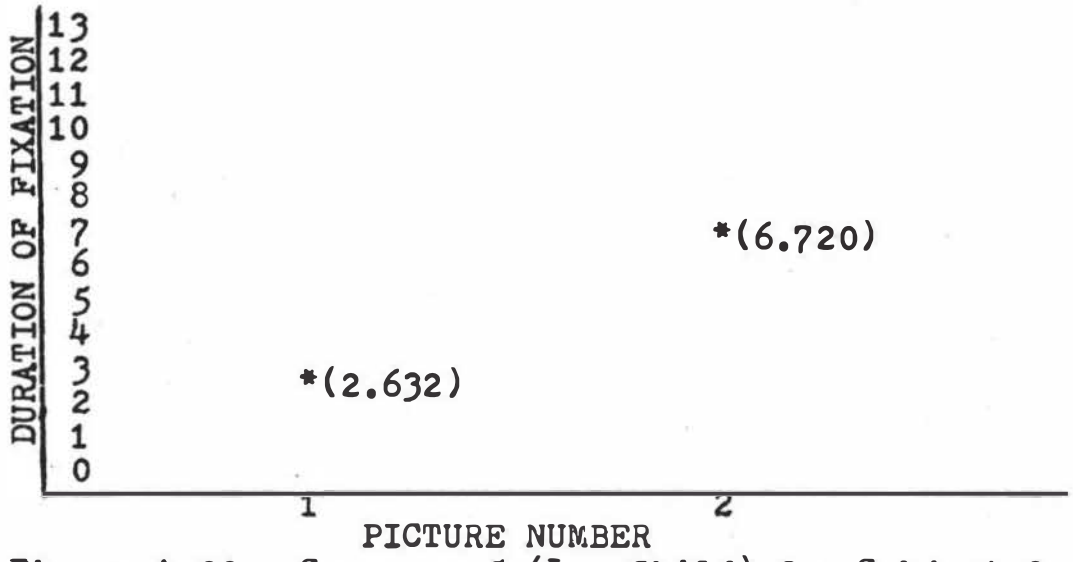

Figure A-22. Sequence 5 (Low Child) for Subject 2.

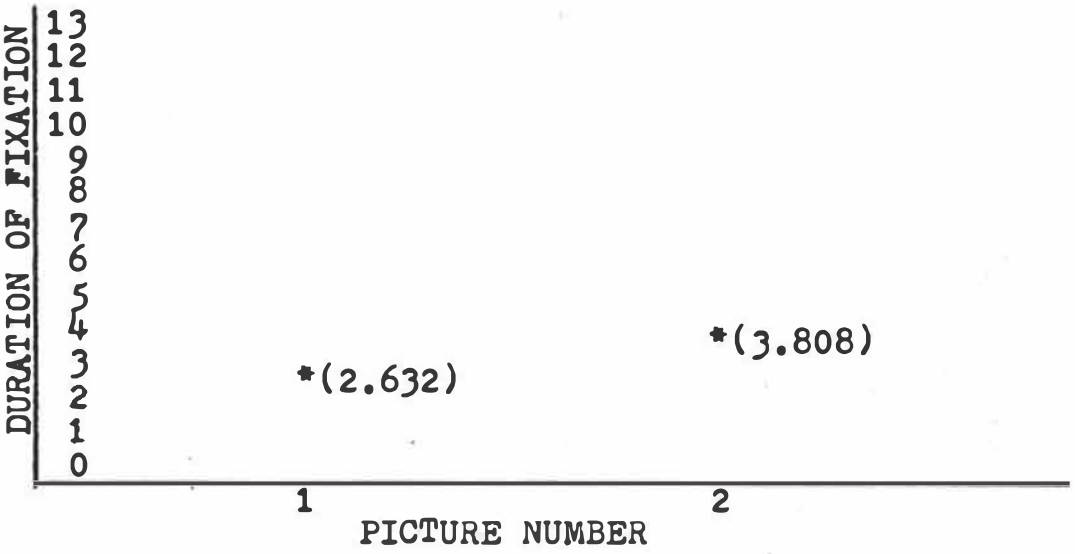

Figure A-23. Sequence 17 (Low Adult) for Subject 2.

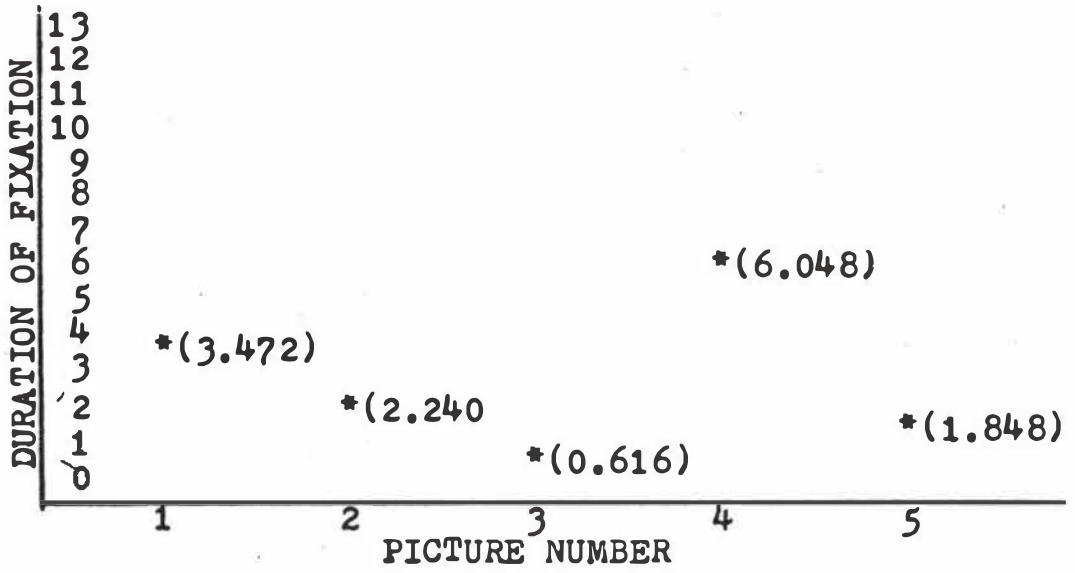

Figure A-24. Sequence 16 (High Adult) for Subject 2.

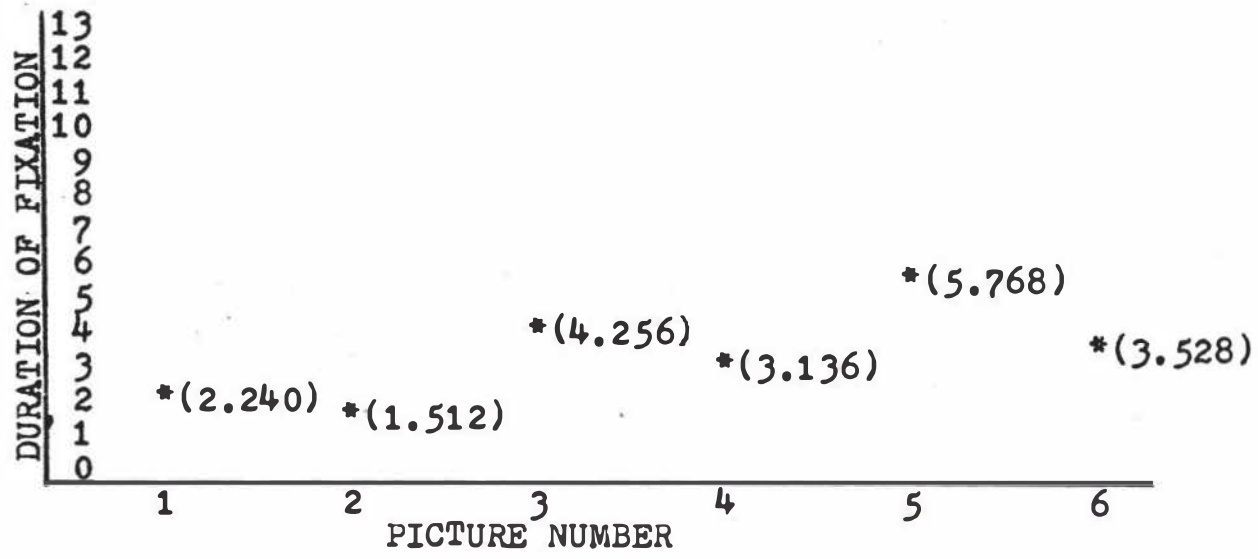

Figure A-25. Sequence 4 (High Child) for Subject 3.

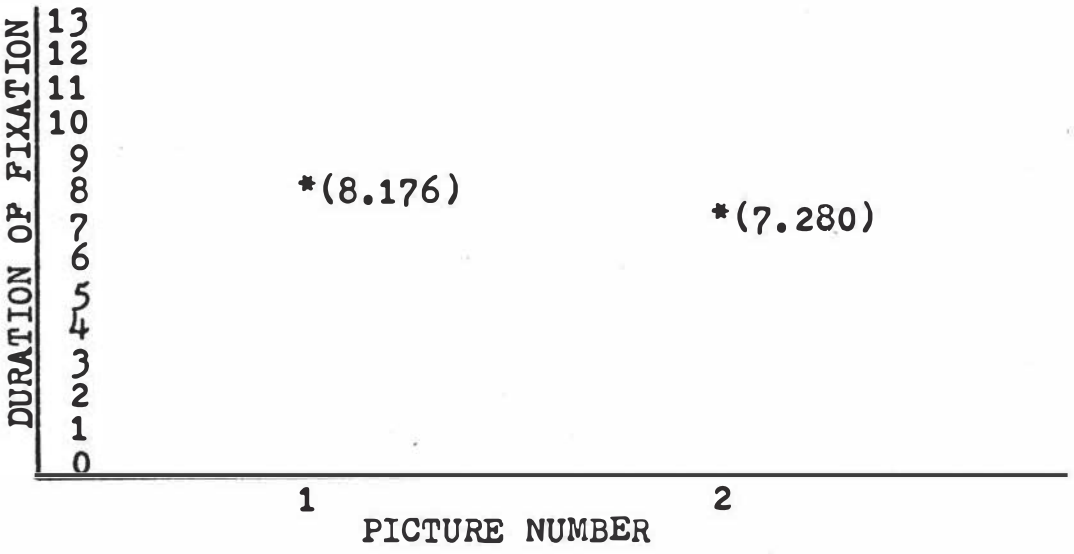

Figure A-26. Sequence 6 (Low Child) for Subject 3.

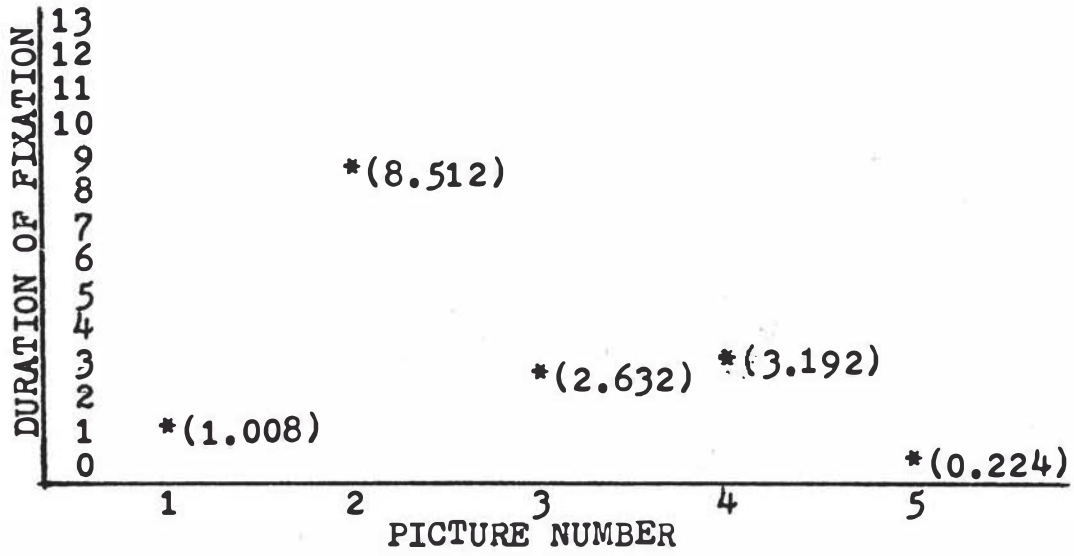

Figure A-27. Sequence 16 (High Adult) for Subject 3.

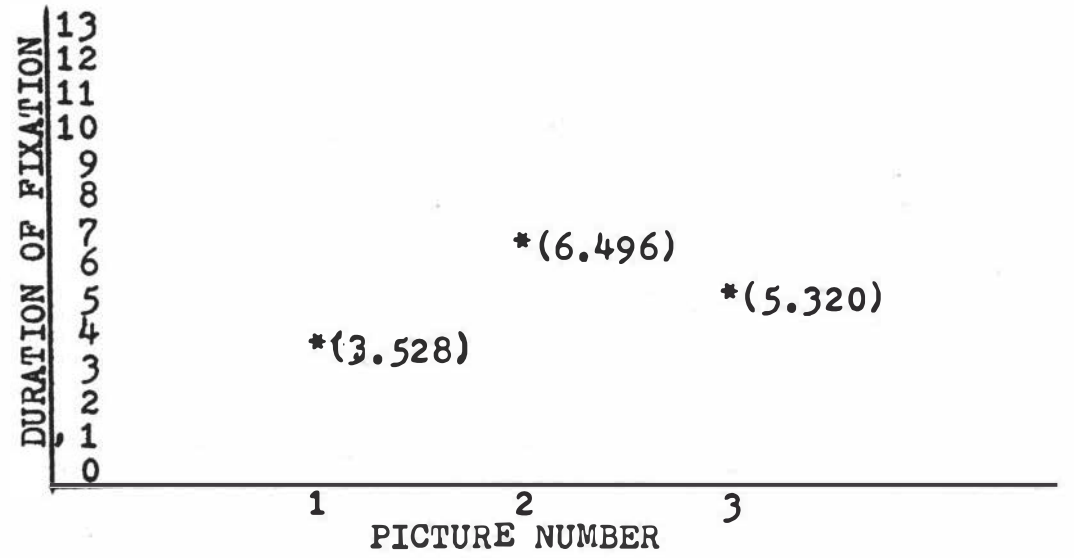

Figure A-28. Sequence 11 (Low Adult) for Subject 3.

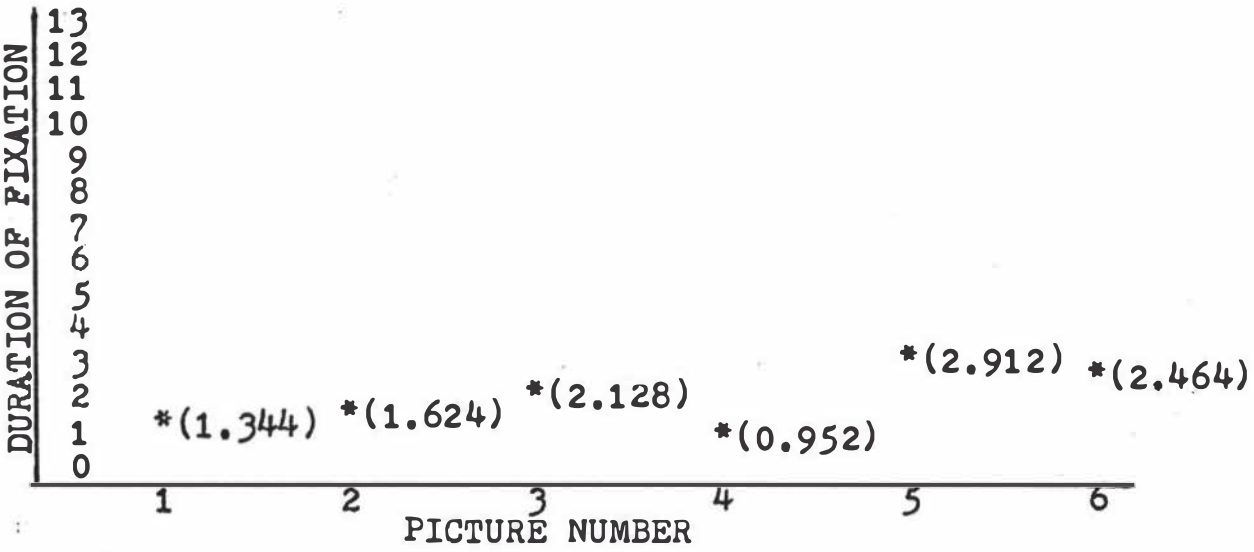

Figure A-29. Sequence 8 (High Child) for Subject 4.

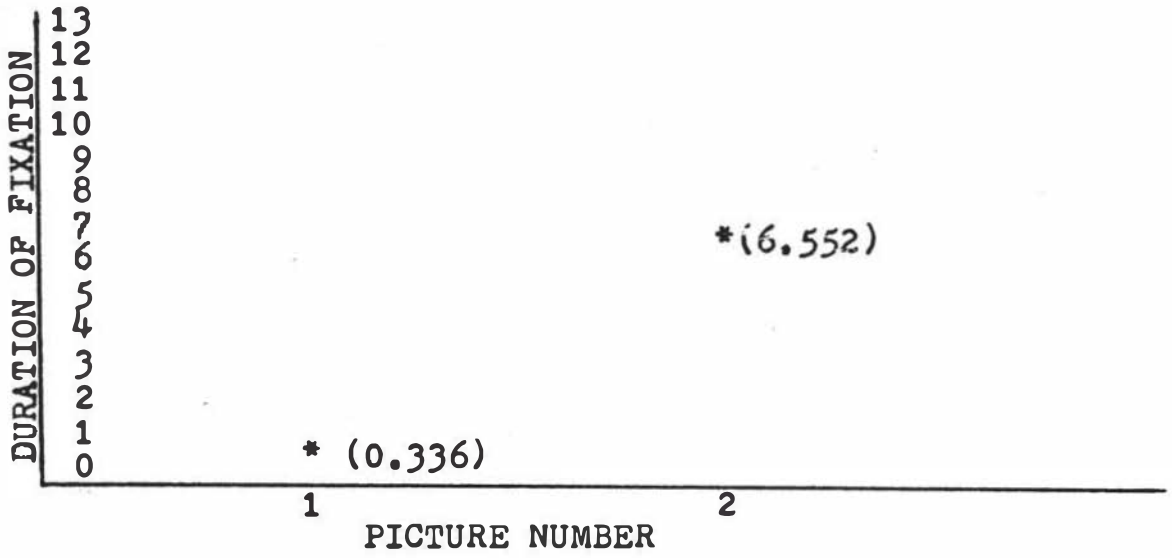

Figure A-30. Sequence 6 (Low Child) for Subject 4.

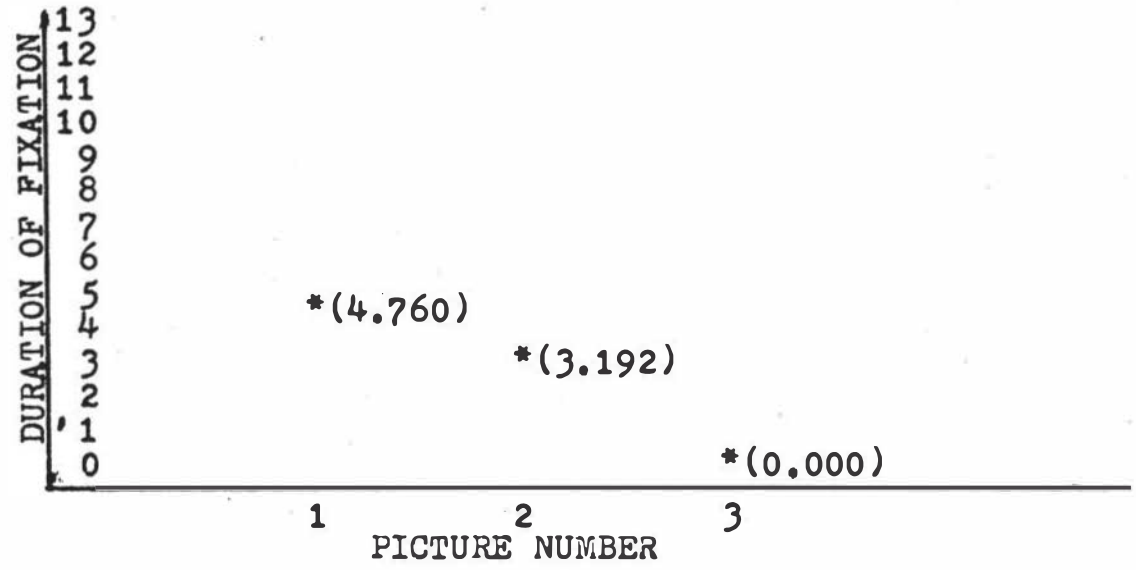

Figure A-31. Sequence 11 (Low Adult) for Subject 4.

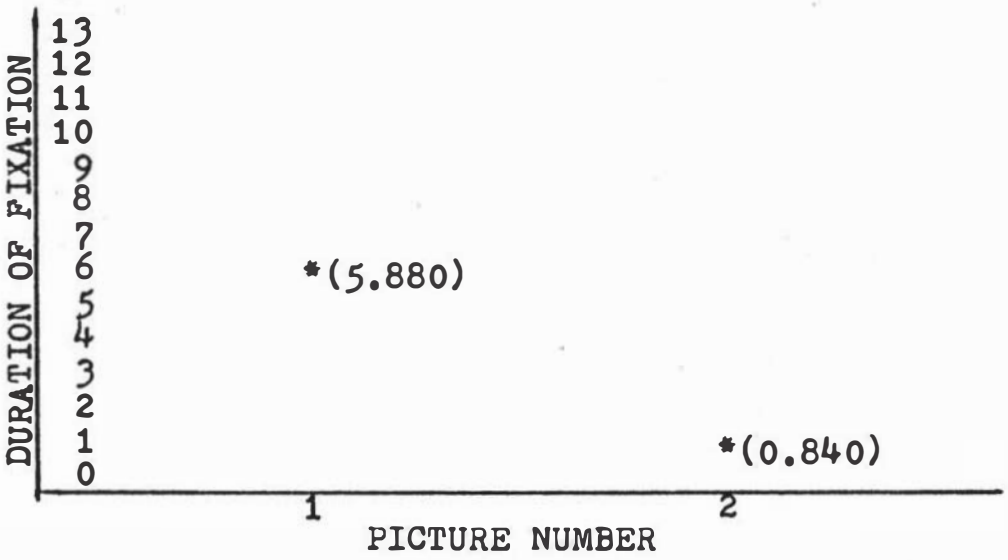

Figure A-32. Sequence 12 (High Adult) for Subject 4.

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