DOCUMENT RESUME

ED 023 483 PS 001 306

By -Lewis, Michael; And Others
Novelty and Familiarity as Determinants of Infant Attention within the First Year.
Temple Univ., Philadelphia, Pa. Fels Research Inst.
Spons Agency -National Inst. of Mental Health (DHEW), Bethesda, Md.
Pub Date [66]
Note -47p.
EDRS Price MF -$0.25 HC -$2.45
Descriptors -Adaptation Level Theory, *Attention Span, Cognitive Development, Eye Fixations, Fixed Sequence, *Infant Behavior, *Infants, Longitudinal Studies, Response Mode, *Stimulus Behavior, *Visual Stimuli

Three related experiments were conducted to investigate the effects of novel and familiar stimuli on infant attention. The procedure in each of the experiments was to place an infant before a matrix panel composed of six rows of six lights. Two patterns of lights were used to obtain the infants' fixation time: (1) a point pattern, a single blinking light in the center of the panel, and (2) a helix pattern, a single blinking light which moved across the board. In experiment one, 122 infants of approximate ages 12, 24, 36, 56, and 68 weeks received four 30-second point pattern trials and a fifth helix pattern trial. Habituation (decrease in fixation time) increased with age of the child. However, no response increment was found upon the change to the novel stimulus (the helix pattern). Experiment two used 80 infants of 3, 6, 9, and 13 months of age. Here, four helix trials were followed by one point pattern trial. The results were similar to experiment one. Experiment three repeated the procedure of experiment one in longitudinal-study form; that is, all of the infants in the experiment were tested at 3, 6, 9, and 13 months of age. The habituation data was similar to experiments one and two in that the younger children showed less habituation. (WD)

# Novelty and Familiarity as Determinants of Infant Attention Within the First Year[1]

Michael Lewis, Susan Goldberg and Marilyn Rausch

Fels Research Institute

In the exploration of stimulus differences in eliciting attention, the dimension of stimulus novelty and familiarity has shown itself to be extremely important. Recent work on this stimulus dimension has been spurred by the theoretical work of Berlyne (1960), Fiske and Maddi (1961), Dember and Earl (1954) and Sokolov (1963). All of these theorists are concerned with the problems of the stimulus determinants of attention, curiosity and exploratory behavior. Moreover, all assume that novelty is one of the stimulus attributes that facilitates attention. While it is agreed that novelty is an important stimulus property for eliciting and sustaining attention, there are a variety of definitions of novelty as well as familiarity which must be explicated in a discussion of these parameters.

In a recent paper (Lewis, 1965), two definitions of novelty and familiarity were suggested, one of which held much in common with Sokolov's theory of the orienting reflex (1963). Borrowing the concept of the orienting reflex from Pavlov, Sokolov states that there are three major classes of responses elicited by stimuli: orientation, defense, and adaptation. The orienting reflex habituates when a stimulus is repeatedly presented and reappears when the stimulus is changed. The orienting reflex, therefore, is directly related to novelty. For Sokolov, a neuronal model is indispensable to his theory of the orienting reflex. He defines a neuronal model as an organization of neural cells in the cortex which retain and process such information as intensity, duration and quality of stimuli. Such a model is developed by the repetition of the same stimulus. Once built up, if the presented stimulus corresponds to the model, some type of negative feedback occurs, resulting in the decrease or absence of a response. This stimulus would be called familiar. However, if the presented stimulus does not correspond with the neuronal model, central excitation takes place and an orienting reflex occurs. This stimulus would be called novel. One operational definition of a familiar stimulus is a repeatedly presented stimulus, while a novel stimulus is a change in that stimulus. To observe the effect of familiarity on infants' attention, one would repeatedly present the same stimulus ($S_1$) for _n_ trials. A novel stimulus and its effect on attention would be observed by presenting $S_2$ on trial *n* + 1. Investigators of the orienting response have, of course, used this paradigm. Its use would also be appropriate for investigating familiarity and novelty.

A second definition of novelty and familiarity rests on the assumption that in the history of the organism certain stimuli have been repeatedly presented either over long or short periods of time. A model or expectation has been established, rendering these stimuli familiar, while others, not presented in the past, are novel. Because it is difficult for the investigator, on an *a priori* basis, to determine what the organism--especially a human infant--has or has not experienced, he is forced to select stimuli with a zero likelihood of having been seen. This usually requires that distortion be presented. Moreover, in order to compare the effect of novel to familiar stimuli, the distortions are usually performed on familiar objects. For studying infants, this has usually meant the human face and body.

It would seem that in both paradigms the violation of expectation is central to the notion of novelty. However, in one it is an expectation built up over a relatively long time and from the events which naturally occur in the infant's environment or which are determined by some basic maturational process. In the other case, expectation is built up in a relatively short time and may be a relatively short-lived expectation. This type of expectation (or model) might not survive the experimental setting in which it was created, while the former type of expectation, built up over a long period, is more lasting. This suggests that one of the basic differences between these two models of novelty and familiarity is based on the duration of the schema or neuronal model. It is postulated, therefore, that in the historical definition of novelty, the schema or structure is long-term while in the experimental definition, the schema or model is short-term.

Fantz (1964) employed a paired comparison technique and was able to show that within a paired presentation, an infant looked longer at a novel stimulus than at the one which had been continuously presented. This was true for infants three months or older, but did not apply to younger infants who showed no response decreases. Saayman, Ames and Moffett (1964) also used a paired comparison technique with 3-month-old infants. The authors found that familiarization led to a decrease in looking over the 4 1/2 minutes of constant presentation. Further, under conditions in which an initially preferred stimulus was familiarized, it was looked at less after familiarization. Finally, in a recent paper, Charlesworth (1966) explored the persistence of orienting and attention to stimulus-locus uncertainty and found that stimulus conditions with high uncertainty are more effective in maintaining orienting and attending behavior than stimulus conditions of low uncertainty. Moreover, the two age levels five to 10 months and 12 to 19 months showed little difference in this response. While this study did investigate some age differences, combining such large age group differences raises serious question as to the lack of age differences in light of the Fantz (1964) finding.

Under this experimental paradigm, several other modalities have been explored; Engen and Lipsitt (1965) and Bridger (1961) showed habituation in the neonate to repeated olfactory stimulation and Engen and Lipsitt were also able to elicit response recovery when the stimulus dimensions were altered. Bartoshuk (1962a, 1962b), using auditory stimuli, demonstrated habituation to repeated stimulation and response recovery when the auditory stimulus was altered. Thus, the existing data on infants, regardless of modality, indicates that familiarity, defined as repeated presentation of the same stimulus, leads to response decrement or habituation, while novelty, defined as altering the presentation, usually leads to recovery of the response.

It is clear from the sparse data available on infants' visual responses that much empirical work need be conducted. While the response to novelty and familiarity has been explored in animals and adults, little work has been conducted with infants in the first two years of life (Cantor, 1965). Moreover, investigation of the developmental change in response to familiarity and novelty has barely been started. The present set of studies was designed to investigate the effects of novelty and familiarity on infant attention and further, to observe any developmental interaction within this stimulus dimension.

## Experiment I

### Method

#### Subjects

In order to observe age differences in response to familiar and novel stimuli, infants from five different age groups were studied. To avoid the effects of past experience, a cross-sectional design was used. A total of 122 different infants were seen at 12 weeks of age (± 4 days), 24 weeks of age (± 7 days), 36 weeks of age (± 7 days), 56 weeks of age (± 9 days) and 68 weeks of age (± 10 days).

#### Apparatus

The seating arrangement varied for each age group. The youngest Ss were placed in a reclining infant seat, the oldest

Ss sat in a high chair. The mother sat to the side and rear of S. The infant and mother were completely enclosed and, except for several observation windows, were surrounded by a uniform grey area. Immediately in front of S and approximately eighteen inches from his head was the matrix panel from which the stimuli were presented. The matrix panel consisted of a plexiglass board and contained six rows of six lights forming a 6 x 6 matrix which was programmed to present any kind of temporal or spatial light pattern. In this experiment, two patterns were used: a single blinking light in the center of the panel (point), and a single blinking light which moved across the board describing a helix. In both patterns the light blinked at a rate of once every other second and there was never more than one light on at a time. In this manner, the light energy (approximately two foot candles) reaching the infant was constant from stimulus to stimulus. The two stimuli used in the present experiment fulfilled the requirement that $S_1$ be discriminable from $S_2$ in that Kagan and Lewis (1965) found that for both six and 13-month-old infants, their patterns of fixation as well as their cardiac response for the point and helix were significantly different.

Procedure

Prior to the presentation of the matrix pattern, each infant was presented with a different set of visual stimuli which lasted approximately 12 minutes. Following this series and prior to the presentation of the light stimuli, each infant rested for approximately 10 minutes. After S was placed in the appropriate position, the light patterns were presented. Five trials, each 30 seconds in duration with a 30-second intertrial interval, were presented.[2] The point pattern was presented for the first four trials and constituted the familiar stimulus. The helix pattern was presented on Trial 5 and constituted the novel stimulus. If S became sleepy or upset during the presentation, the episode was terminated and started again when S was in an alert state.

Measures

The most frequently used operational definition of fixation is the amount of time the stimulus overlaps the infant's cornea (Hershenson, 1964; Fantz, 1956, 1963a, 1963b, 1964; Stechler, 1964). Quantification of this variable ranges from the use of human observers to cinematographic recording of the eyes to determine whether the stimulus is isomorphic with the infant's pupil (Hershenson, 1964). Filming is obviously more objective, but the inter-scorer reliability for human observers is generally very high (Fantz, 1956; Saayman, *et al.*, 1964; Cantor & Myers, 1965). Moreover, the photographic technique necessitates fixing or severely limiting the infant's movements, which in older infants often results in frustration and termination of the experimental session. The alternative procedure of recording the amount of time the infant turns his head and eyes toward the stimuli yields high interobserver reliabilities and has the advantage of allowing the infant maximum movement (see Lewis, Myers, Kagan & Grossberg, 1963; Lewis, Kagan & Kalafat, 1966), a necessary condition when dealing with infants who are sufficiently mature to move about freely. Another advantage of this technique is that it allows assessment of cardiac reactions as a measure of attention. Any limitation on *S*'s activity imposes a serious bias on the cardiac data. For these reasons, fixation was measured by two independent observers who recorded the amount of time *S* turned his head and eyes toward the stimulus.

Total fixation (TF) was obtained by two independent observers who were unaware of the stimulus being presented. Each time *S* oriented his head and eyes toward the array, the observers depressed a key marking the duration of that fixation on an event recorder. The interscorer reliability for TF was $r = .94$. First fixation (FF), or the length of time S oriented toward the array before first turning away, was also recorded. Interscorer reliability for FF was $r$ = .91.

## Results

Figure 1 presents the best fit linear regression line for the total fixation time for each age. The standard error of estimate, varying from .82 - 1.35 seconds around the regression line, indicates that a linear function does offer a good fit for the fixation data.

The data for the first four trials demonstrate the effect of familiarity or repeated stimulation, while the data from the fifth trial indicate the effect of novelty or violation of repeated presentation. The data for the first four trials indicate a direct relation between the rate of habituation to repeated stimulation and the infant's age. Table 1 presents for TF the function of the linear regression and the standard error of estimate (SE). The slope value, $a$, revealed that the 3-month-old infants showed the least habituation followed by the 6-, 9-, 18- and 13-month-olds. Table 1 also presents the habituation data in another form for both TF and FF data. In this analysis of habituation, the fixation time of the fourth trial was subtracted from the fixation time of the first trial and the mean difference score for each age was obtained. Negative values and relatively small positive values indicate little or no habituation, while large positive values indicate relatively great habituation. The TF difference data parallel the slope data and indicate that habituation to repeated stimulation is a function of age, the younger infants showing less habituation than the older ones.

In order to test these differences in rate of habituation, the individual difference scores (Trial 1-4) were compared by using the Kruskal-Wallis one-way analysis of variance (Siegel, 1956). All of the Kruskal-Wallis and Mann-Whitney tests presented in this paper are two-tailed. The data indicate a significant difference between the age groups ($p<.001$) in their rate of habituation to repeated stimulation. Moreover, individual Mann-Whitney $U$ tests (Siegel, 1956) revealed that the 3-month data were significantly different from the 9-month ($p<.04$), 13-month ($p<.005$), and 18-month data ($p<.005$). Further, the 6-month data were significantly different from the 13-month ($p<.005$) and 18-month data ($p<.05$) and the 9-month data was significantly different from the 13-month data ($p<.05$). While all other test results were in the predicted direction, none of them reached significance.

Although the data clearly indicate that the change scores are related to age, it is necessary to insure that the scaling problem of initial looking level is not involved. It could be argued that Ss who initially looked less could not habituate as rapidly as Ss whose initial look was relatively great. The data of Figure 1, however, dispel this possibility in that the 3-month-olds looked the most but habituated the least. Moreover, the correlation between fixation on Trial 1 and fixation differences between Trials 1 minus 4 is rho = -.20 and indicates no relation between these two variables. A statistical correction for initial level is to divide the 1-4 difference by the value of Trial 1. These data, called corrected TF, are presented in Table 1 and indicate that the age x habituation interaction is still linear.

The uncorrected FF data (see Table 1) failed to indicate a consistent age x habituation effect; however, the corrected FF data also indicate that the rate of habituation to repeated stimulation increased as a function of age.

The response to the novel stimulus can be assessed in at least three different ways. First, the data from the fifth trial (novel) can be compared to the predicted point of the best fit line for each age group. If the observed point is more than two standard deviations from this point, it can be assumed to be a significant deviation. The second procedure is to observe the rate of change. That is, to obtain a difference score between trials 3-4 and compare that difference to the 4-5 trial difference. It would be predicted that a significant difference in the rate of change would reflect a differential response to novelty. Finally, the observation of the number of subjects showing differential looking times on Trial 5 as compared to Trial 4 could be tested by the formula $\Sigma \frac{|O-E|^2}{E}$ (Siegel, 1956), assuming the expected probabilities to be .50. The disadvantage of this procedure is in determining the expected probability (E). While .50 is probably appropriate for analysis when there are more Ss increasing than decreasing their fixation times on Trial 5, it is not appropriate in the reverse situation in that decreased fixation is the more appropriate response to repeated stimulation.

The response to the novel stimulus can be detected by observing the fifth trial in Figure 1. The data indicate that the fifth trial does not deviate from the best fit line for each of the age groups with the exception of the 6-month group whose TF on the fifth trial is greater than two standard deviations below the point predicted by the best fit function. In that response recovery was predicted when a novel stimulus was presented, the present results are most unaccountable.

A differential response to novelty was not observed using the rate of change analysis. A Wilcoxin test for matched pairs (Siegel, 1956) for each age group separately revealed no significant differences for any of the ages.

Finally, the number of Ss showing change data indicate no significant differences for any of the ages except the 6-month-old Ss where five Ss showed increases and 15 Ss showed decreases. A chi square test, using the above analyses with the E = .50, 1 df, indicates a significant decrease ($X^2 = 5.00$, $p < .05$). However, .50 may be too conservative and the significance level of the 6-month data must be viewed cautiously.

Discussion

The effect of familiarization is habituation and is directly related to age, the younger infants showing less habituation than the older infants.

In general, all three measures of change to the novel stimulus indicate a lack of response increment and the 6-month data suggest a response decrement.

A second study was performed to investigate this failure as well as to study further the habituation x age effect. Moreover, in that Cohen (1965) and Ames (1966) have shown that complexity can affect the rate of habituation, the familiar stimulus was the relatively more complex helix pattern while the novel stimulus was the point pattern. Thus, the present experiment transposed the order of Experiment I. Moreover, by presenting the relatively complex pattern first, the effect of a novel simple pattern preceded by a familiar complex pattern was assessed against Experiment I where a novel complex pattern preceded the familiar simple pattern.

## Experiment II

### Method

#### Subjects

Eighty Ss, 20 at three, six, nine and 13 months, were seen in Experiment II.

#### Procedure

The apparatus and procedure were exactly the same as those used in the previous experiment. The only difference was in the order of presentation. In this experiment, four helix trials were first presented followed by the point trial. The helix thus constituted the familiar pattern and the point was novel.

#### Results

Figure 2 presents the best fit linear regression line for the total fixation time for each age. The standard error of estimate again indicates that a linear function does offer a good fit (.36 - 2.00 sec.). The data for the first four trials indicates a relation between rate of habituation and age. Observation of the slope values a in Table 2 indicates that 3-month-old infants show the least habituation and that habituation increases with age. The slope data also indicate that unlike Experiment I, the 13-month-old infants' habituation rate is not greater than that of the other age groups. In fact, the TF data indicate that it is most similar to the 3-month-old data.

The other measure of habituation (i.e., Trial 1-4) also indicates that 3-month-olds show the least habituation and that habituation increases as a function of age, at least for the first nine months. In order to test these differential rates of habituation a Kruskal-Wallis one-way analysis of variance test was applied to the difference scores and the results indicate that there were significant differences between the age groups ($p<.05$). The corrected difference scores showed the same results. Individual Mann-Whitney U tests revealed that the only significant differences existed between the 3- and 6-month-olds ($p<.05$) and the 3- and 9-month-olds ($p<.05$). While the habituation rate of 13-month-olds was more gradual than that of the 6- and 9-month-olds, it was not significantly different. However, this is due to an increase in looking on Trial 4 for the 13-month-olds. If Trial 1-3 differences are compared, the difference scores are: 3M (2.3 sec), 6M (4.1 sec), 9M (8.9 sec) and 13 M (7.7 sec).

The uncorrected FF data (also shown in Table 2) failed to show any ordered age effect. However, the corrected FF data is ordered similarly to the TF data and indicate that habituation rate increases as a function of age.

Since there may be an age x habituation x stimuli complexity interaction, it was necessary to determine whether the helix or point pattern produced differential habituation rates. For this comparison each S's 3-month habituation data (Trials 1-4) from Experiment I was compared to the 3-month habituation data from Experiment II. This was also done for the 6-, 9- and 13-month data. The results indicate that there were no significant differences in habituation rate between the same age Ss in Experiments I and II. Moreover, an analysis of variance with age and stimulus as main effects failed to show a significant interaction.

The response to the novel stimulus was first determined by observing the best fit data and the discrepancy between the predicted and observed fixation time for the fifth trial (see Figure 2). The data indicate that for the 6-, 9- and 13-month-old infants, the response to the fifth trial (the novel trial) does not deviate from the best fit line. In each of these cases the difference is less than one standard deviation from the predicted point. The response of the 3-month-old infants indicates an increase in fixation to the novel stimulus. This increase represents a positive change which is more than 17 standard deviations from the predicted best fit line and therefore indicates a significant increase in looking when the novel stimulus is presented.

The rate of change analysis data indicate no significant increases or decreases for 3- and 6-month-old infants. For both 9- and 13-month-old infants, the data indicate a significant decrease in the response to Trial 5 (Wilcoxin test, $p<.05$, two tailed).

Finally, the number of Ss showing change in fixation time on Trial 5 was compared to Trial 4 by a chi square analysis. The results show significantly more 3-month-old Ss increasing than decreasing their fixation time ($X^2 = 6.40$, 1 df, $p < .05$) while the 9- and 13-month-old Ss show significantly more decrease than increase in fixation time ($X^2 = 6.40$, 1 df, $p < .05$ respectively). There were no significant differences for the 6-month-olds.

## Discussion

The data from both experiments for the rate of habituation to repeated stimulation show that younger infants habituate less than do older infants within the first year. In terms of measurement, both FF and TF resulted in the same age ordering and indicate that habituation rate is independent of the measure of fixation used. However, while the corrected and uncorrected TF data yielded the same results, the corrected and uncorrected FF were different. Thus, the initial amount of fixation affects the rate of habituation for the FF measure but not for the TF measure of fixation. The present data suggest that these measures of fixation are not totally similar and may reflect different attentional processes (Lewis, Kagan, and Kalafat, 1966).

The habituation rate was also independent of the nature of the stimulus. That is, both the pattern of a stationary blinking light (point) or the moving blinking light (helix) elicited the same rate of habituation. That the moving blinking light did not elicit less habituation than the stationary light is inconsistent with the findings of Cohen (1965) and Ames (1966) who found a habituation x stimulus complexity effect. Thus, the present data provide no support for a complexity effect on the rate of habituation.

The response to the novel stimulus was not clear. First, the 3-month-olds showed response recovery for two of the three measures in this experiment, but showed no response recovery in Experiment I. None of the measures in this experiment revealed any changes in the response of 6-month-olds, but two measures in Experiment I did. Moreover, the 9- and 13-month-olds showed response decrement under two of the analyses in this experiment, but no change in the first experiment. The fixation data for the two experiments show no consistency and raise several questions about the failure of the novel stimulus to elicit response recovery, as well as the occurence of response decrement. One possibility is that the response measure of fixation is not sufficient to isolate the response to novel stimuli. That is, recording orientation of the head and eyes is not sufficient to establish stimulus differentiation and response recovery. Indeed, Lewis (Lewis, _et al_., 1966; Lewis, 1966) has shown that multiple response measures are extremely important in measuring infant behavior since a response can have multiple meaning; that is, it can be under the service of more than one response system. It might be that infants do not need to look longer in order to respond to novel stimuli, and some internal response of attending might indicate recovery where fixation alone would not. One such measure of attending is the cardiac response. Several recent papers have shown this to be an important measure and one sensitive to changes in stimulation in cases where fixation was not (Lewis, 1966; Kagan, _et al_., 1966). Experiment III was designed to use two response measures (cardiac response and orientation) in order to observe the response to novelty and familiarity.

## Experiment III

### Method

#### Subjects

While Experiments I and II were cross-sectional, a longitudinal study would supply added evidence on the age x habituation relation. Seven infants were seen at three and six months of age, six of these were seen at nine months and five were seen at 13 months. The families of one 9-month-old S and one 13-month-old S moved, producing the uneven n's. The restrictions on the age when tested were the same as in the first two experiments.

#### Procedure

The same procedure as described in Experiments I and II were used in this experiment. The order of presentation was the same as in Experiment I, i.e., four point trials followed by a helix trial.

#### Measures

In addition to the fixation measure, Ss' heart rate was recorded. Lewis, Kagan, Campbell and Kalafat (1966) and Lewis and Spaulding (1966) have shown in several recent studies that in infants' cardiac deceleration occurred when they attended to visual and auditory inputs. Moreover, the magnitude of the cardiac response was directly related to the length of the fixation, with longer fixations resulting in greater deceleration.

In order to obtain the cardiac response, electrodes were attached to S and the cardiac response was recorded both on a punch paper tape system and on a polygraph. By use of a Fels Cardiotachometer, the cycle to cycle interval (r-r interval) was converted to a rate per minute score providing a continuous monitoring of the cycle to cycle cardiac rate. Also automatically recorded on both the polygraph and punch paper tape was the onset and duration of each stimulus period as well as whether or not S was oriented toward the array.

In the analysis, the mean of the last three beats (r-r intervals) prior to stimulation was compared to the mean of the three lowest beats (r-r intervals) during stimulation and during the time S oriented toward the array. The mean cardiac rate prior to looking was subtracted from the mean cardiac rate during looking and the difference score constituted the cardiac response to stimulation. As for fixation, it was predicted that familiar stimuli would elicit less deceleration than novel stimuli. The cardiac deceleration response, therefore, would be expected to habituate over trials and recover when the novel stimulus was presented.

## Results

### Fixation Data

Figure 3 presents the best fit linear regression line for the total fixation data as well as the cardiac data. The fixation data for this figure is presented in Table 3. Because of the small number of Ss, the standard error of estimate for the four age groups is relatively high, varying from 0.84 to 3.12 seconds of fixation. The slope data, a, indicate that the 3-month-olds showed less habituation than the other three age groups and therefore replicate the findings of Experiments I and II.

The corrected and uncorrected TF difference data (Trial 1-4) parallel the slope data. A Friedman two-way analysis of variance (Siegel, 1956) was performed to test these habituation differences. However, because this test requires equal numbers of Ss at each age level, the two infants not seen at nine and 13 months were removed from the 3- and 6-month data. The results indicate significant age differences ($X_r^2 = 9.30$, $p < .02$). Moreover, individual sign tests between the groups indicated significant 3-6 month ($p<.05$) and 3-9 month ($p<.01$) differences. These results held for both corrected as well as uncorrected data.

The results of the FF, both corrected and uncorrected, were different from the TF data. The corrected FF data indicate a consistent increase in habituation as a function of age across the entire first year ($X_r^2 = 8.74$, $p < .02$). Thus, these data replicate the findings of Experiment I which also showed a perfect ordering from three to 13 months.

The response to the novel stimulus is apparent in the fifth trial in Figure 3. This trial does not deviate from the predicted best fit line for any of the age groups. The apparent differences all represent less than one standard deviation from the predicted point. Moreover, the rate of change between Trials 3-4 and 4-5 as well as the number of Ss showing changes to Trial 5 as compared to 4 all showed no significant differences and as such are in agreement with the best fit data.

Cardiac Data

Figure 3 also presents the best fit line for the cardiac data. These curves were determined by computing a difference score for every trial for each infant. The scores were obtained by subtracting the mean of the last three beats prior to stimulation from the mean of the lowest three beats during stimulation. A minus value signified that the mean value during stimulation was lower than the mean value prior to stimulation and therefore indicated deceleration, the larger minus value indicating greater deceleration. The mean difference value for each trial within an age group was then computed and these values were used to determine the best fit lines presented in Figure 3.

In that deceleration usually accompanies fixation, one would expect deceleration to occur and as fixation decreases (as a function of familiarity), the amount of cardiac deceleration should decrease. That is, the deceleration response should habituate. Moreover, once a new stimulus is introduced, response recovery both of fixation and of cardiac deceleration should occur. The best fit data for each age group for the repeated trial data indicate that the cardiac deceleration response does not habituate over trials and that there are no significant age differences in the rate of habituation, although 6-month-olds showed the sharpest decline in cardiac response.

The data for these functions are presented in Table 3. The standard error of estimate scores was the highest for any of the three samples varying from 1.12 to 3.85 b.p.m. around the best fit line. Because of the relatively poor fit of a linear function, the mean difference data by trial and age are presented in Table 4.

Observation of Table 4 indicates the reason that the linear regression was a poor fit for the cardiac data. In general, there is appreciably less cardiac deceleration on the first trial than on the second. The explanation of this phenomenon can only be post hoc; however, other studies have also encountered it. Because the first trial often produces responses inconsistent with the subsequent series presentation, it has been excluded (Kagan, Henker, Hen-Tov, Levine & Lewis, 1966). If, instead of viewing the data from Trial 1, one begins at Trial 2, one finds, in general, a more linear habituation of the cardiac response with each age group showing less habituation on Trial 4 than on Trial 2. The data also indicates that the 6-, 9- and 13-month-old infants all show a monotonic decrease in the cardiac response, while the 3-month-olds show no such monotonic function. Moreover, if the fourth trial is subtracted from the second, the difference scores (see Table 3) indicate that 3-month-olds show the least cardiac response habituation (that is, a change of only 2.10 b.p.m. less on Trial 4 than on Trial 2), the 9-month-olds next, 13-month-olds next and the 6-month-olds, the most. Thus, the cardiac response data from the second trial parallel the fixation data and suggest an age x habituation rate interaction.

Figure 3 presents the response to the novel stimulus on Trial 5. The cardiac deceleration response for the 3- and 6-month-old infants shows a recovery which is as high or higher than the initial cardiac response. The 3-month-olds' response to the novel stimuli is 1.8 standard deviations from the predicted best fit point, while the 6-month data is more than 10 standard deviations from the predicted point. The 9- and 13-month data indicate that there is no difference between the predicted and observed response to the novel stimulus. The rate of change data as well as the number of infants showing cardiac changes on Trial 5 revealed no significant differences.

The final analysis compared the two measures of response, fixation and cardiac deceleration, and revealed little relation between them. The rho's for Trials 1-4 ranged from +.50 to -.50, none of which was significant.

Discussion

Generally, the effect of familiarity is response decrement. This phenomenon can be observed across two response measures of fixation, as well as for the cardiac deceleration response. The results indicate that there are significant age differences in rate of habituation, the younger infants showing less habituation than the older infants within the first 18 months of life. Moreover, the data from each of the three experiments suggest a continuum of habituation which is directly related to age, that is, a generally monotonic ordering within the first year of life.

The meaning of this phenomenon is not clear. Sokolov (1963) suggests that central processes such as neuronal models (memory or storage of information) are involved in response decrement to repeated stimulation. Moreover, a growing body of neurophysiological data is demonstrating important central changes as functions of the organism's building up expectation through repetitive stimulus presentation (Walters, 1964). If we apply these models of behavior to the present age differences, the results suggest that younger infants do not build up models or expectations as rapidly as older infants. Two possible explanations might account for this. One is that more trials are needed to render the stimulus event familiar. To date, this hypothesis seems unfounded in that an experiment in progress, using nine repeated point pattern trials, also indicates significant age differences, the older infants showing greater habituation than younger ones. The mean difference for trials 1-9 in the 3-month group is -1.1 as compared to -2.9 for the 1-4 trial difference. For 13-month-olds, the comparable difference scores are +8.5 and +0.5. Thus, while number of trials may be an important variable, at least doubling the present number does not seem to eliminate the age difference. A second possibility is that a shorter intertrial interval is necessary to maintain a memory trace. This is especially true in the present experiment where a 30-second intertrial interval is used, an interval which may be too long for a very young infant's memory storage system. If this is the case, each repeated trial represents a new event to the young infant. While no experiment varying the intertrial interval has been performed using infants as Ss, Saayman, et al. (1964) produced habituation in 3-month-olds by using one long trial of approximately four minutes. One could think of one long trial as having a 0-second intertrial interval length. Moreover, data for adult Ss clearly indicate marked response decrement as a function of shortening the intertrial interval (Geer, 1966).

A second central process difference might lie in the differential processing of information. While younger infants orient longer toward the visual array, their looking could be an empty stare. However, the cardiac data of Experiment III indicate that the younger infants were "taking in" the stimulus since cardiac deceleration has been associated with this process (Lacey, Kagan, Lacey & Moss, 1963).

Finally, the age differences might be explained in terms of some sort of pleasure principle. Younger infants may "know" they are seeing the same stimulus but continue to enjoy seeing it, whereas the older infants dislike seeing the same stimulus repeated. This explanation would rely on a preference rather than a memory construct.

Another explanation of differential response decrement has little to do with any central process, but rather with differential rates of physical fatigue (restlessness at being in one position, for example). While this is possible, several important facts argue against this hypothesis. First, each infant was placed in a position commensurate with its age--3-month-olds were in a reclining position in an infant seat; 6-month-olds were also in an infant seat, but in a more upright position; 9-month-olds were placed in an infant feeder, while 13-month-olds were placed either in the feeder or in a high chair. Each infant was thus placed in a position that was most comfortable for him, and when a particular position was found uncomfortable, it was changed until a comfortable one was found. Second, the length of experimental time was only four minutes, hardly long enough for much restlessness. Cohen (1965) investigated the effect of restlessness by starting some control subjects at the time equivalent of Trial 21 of an experimental group. In Cohen's experiment, the control infants just sat for the time equivalent of 21 trials in order to see whether their response to the first presentation corresponded to Trial 1 or Trial 21 of the experimental group. It corresponded to the first experimental trial and the restlessness hypothesis as an explanation of habituation was rejected.

A fifth possible explanation also relates to physical rather than central processes. It could be maintained that since only the younger infants were physically unable to turn away and attend to other aspects of their visual environment, they remained captured by the stimulus. One way to examine this contention is to analyze the infant's responses during the intertrial interval period. If the infant was trapped by his lack of physical development, he should look as much during the base period (when no stimulus was showing) as during stimulation. In order to observe whether there were any significant differences the 3- and 13-month data of Sample I were examined. The total amount of fixation during base was compared to that during stimulation and each subject at three and 13 months showed more fixation during stimulation than during base. Moreover, the distribution of ratios of fixation during base to fixation during stimulation for 3-month-old infants is not significantly different from the 13-month-old infants (by Mann-Whitney U test). The range of this percentage score for 3-month-olds varied from 20 to 78 per cent, while for 13-month-olds, it varied from 30 to 83 per cent. Thus, the data revealed no age difference in the distribution of fixation between stimulation and base. This analysis provides important indications that the infant's fixation during stimulation was a product of the appearance of a visual pattern rather than of any physical inability to turn away or of fatigue.

The data for the response to novelty is not clear. The older infants showed neither fixation increases (although there was response decrement), nor cardiac rate changes to the violation, while the younger infants did show both cardiac and fixation changes although not always response increment. Thus, the data offer no clear picture as to the effect of novelty on response recovery. Moreover, the data provide little explanation of the differential habituation rate as a function of age. The failure of $S_2$ to elicit consistent age differences as well as consistent response increases or decreases suggests that response recovery is a more complicated phenomenon than thought, especially for infants within the first year.

An explanation of the failure of $S_2$ to elicit consistent response increment cannot rest on the infants' inability to discriminate between $S_1$ and $S_2$ in that Kagan and Lewis (1965) have clearly shown both significant fixation and cardiac response to these same stimuli. An alternative hypothesis is suggested by James' discussion of attention (1890). James commented that stimuli which are "very intense, voluminous, or sudden...[have] a directly exciting quality" (p. 417) that elicits attention with or without the organism's consent. James called the response to such stimuli "passive immediate sensorial attention," as distinguished from active or voluntary attention based on some motive or association and requiring effort on the part of the attender. It is hypothesized that such "directly exciting" stimuli are more likely to elicit increased attention in the young infant whereas a non-"directly exciting" $S_2$, though discriminable from $S_1$, would not.

It is clear that any attempt to explain the failure of $S_2$ to produce a response increment must be post hoc. The lack of short term memory, the stimulus and temporal parameters, as well as the measures used are all subject to investigation before any clear statement can be made. However, it is clear, at least for the more than 200 Ss in these studies, that any violation of $S_1$ by any $S_2$ (assuming $S_2$ is discriminable from $S_1$) is not sufficient to produce response increment. The important variables, whether subject or experimental, still need to be explored.

## References


Ames, E. W. Stimulus complexity and age of infants as determinants of the rate of habituation of visual fixation. Paper presented at the Western Psychological Association, Longbeach, California, April, 1966.

Bartoshuk, A.K. Human neonatal cardiac acceleration to sound: Habituation and dishabituation. _Percept. mot. Skills_, 1962, 15, 15-27 (a).

Bartoshuk, A.K. Response decrement with repeated elicitation of human neonatal cardiac acceleration to sound. _J. comp. physiol. Psychol._, 1962, 55, 9-13 (b).

Berlyne, D.E. _Conflict, arousal and curiosity_. New York: McGraw-Hill, 1960.

Bridger, W.H. Sensory habituation and discrimination in the human neonate. _Amer. J. Psychiat._, 1961, 117, 991-996.

Cantor, G.N. Responses of infants and children to complex and novel stimulation. In L. P. Lipsitt and C.C. Spiker (Eds.), _Advances in child development and behavior_. New York: Academic Press, 1963. Pp. 1-30.

Cantor, G.N. & Myers, W.J. Inter-observer reliability in judging infants' observing responses. Soc. Res. Child Develpm. Meeting, Minneapolis, Minnesota, 1965.

Charlesworth, W.R. Persistence of orienting and attending behavior in infants as a function of stimulus-locus uncertainty. *Child Develpm.*, 1966, 37, 473-492.

Cohen, L. B. Observing responses, visual preferences and habituation to visual stimuli in infants. Unpublished Ph.D. Thesis, U.C.L.A., 1965.

Dember, W.N. & Earl, R.W. Analysis of exploratory, manipulatory and curiosity behavior. *Psychol. Rev.*, 1957, 64, 91-96.

Engen, T. & Lipsitt, L. P. Decrement and recovery of responses to olfactory stimuli in the human neonate. *J. comp. physiol. Psychol.*, 1965, 59, 312-316.

Fantz, R. L. A method for studying early visual development. *Percept. mot. Skills*, 1956, 6, 13-15.

Fantz, R.L. Pattern vision in newborn infants. *Science*, 1963, 140, 296 (a).

Fantz, R.L. Study of visual perception and the effects of visual exposure in early infancy. Paper read at the American Psychological Association Meeting, Symposium on Infant Attention, Philadelphia, 1963 (b).

Fantz, R. L. Visual experience in infants: Decreased attention to familiar patterns relative to novel ones. *Science*, 1964, 146, 668-670.

Fiske, D.W. & Maddi, S.R. Functions of varied experience. Homewood, Ill.: Dorsey, 1961.

Geer, J. H. Effect of interstimulus intervals and rest-period length upon habituation of the orienting response. J. exp. Psychol., 1966, 72, 617-619.

Hershenson, M. Visual discrimination in the human newborn. J. comp. physiol. Psychol., 1964, 58, 270-276.

James, W. The principles of psychology. New York: Henry Holt & Co., 1890.

Kagan, J. & Lewis, M. Studies of attention in the human infant. Merrill-Palmer Quarterly, 1965, 11, 95-127.

Kagan, J., Henker, B., Hen-Tov, A., Levine, J. & Lewis, M. Infants' differential reactions to familiar and distorted faces. Child Develpm., 1966, 37, 519-532.

Lacey, J. I., Kagan, J., Lacey, B.C. & Moss, H.A. Situational determinants and behavioral correlates of autonomic response patterns. In P.H. Knapp (Ed.) Expression of emotions in man. New York: International University Press, 1963. Pp. 161-196.

Lewis, M., Meyers, W., Kagan, J. & Grossberg, R. Attention to visual patterns in infants. Paper presented at American Psychological Association Meeting, Symposium on Infant Attention, Philadelphia, 1963.

Lewis, M. Exploratory studies in the development of a face schema. Paper presented at American Psychological Association Meeting, Symposium on the Origins of Social Behavior, Chicago, 1965.

Lewis, M., Kagan, J., Campbell, H. & Kalafat, J. The cardiac response as a correlate of attention in infants. Child Develpm., 1966, 37, 63-71.

Lewis, M., Kagan, J. & Kalafat, J. Patterns of fixation in infants. Child Develpm., 1966, 37, 331-341.

Lewis, M. The meaning of a response or why researchers in infant behavior should be oriental metaphysicians. Paper presented at the Merrill-Palmer Conference, Detroit, February, 1966. Merrill-Palmer Quarterly, in press.

Lewis, M. & Spaulding, S.J. Differential cardiac response to visual and auditory stimulation in the young child. Psychophysiol., in press.

Saayman, G., Ames, E.W. & Moffett, A. Response to novelty as an indicator of visual discrimination in the human infant. J. exp. child Develpm., 1964, 1, 189-198.

Siegel, S. Nonparametric statistics for the behavioral sciences. New York: McGraw-Hill, 1956.

Sokolov, Ye. N. Perception and the conditioned reflex. S. W. Waydenfeld (Trans.). New York: MacMillan Co., 1963.

Stechler, G. Newborn attention as affected by medication during labor. Science, 1964, 144, 315-317.

Walter, W. G. The convergence and interaction of visual, auditory, and tactual responses in human nonspecific cortex. In H. E. Whipple (Ed.), Sensory evoked response in man. Ann. N.Y. Acad. Sci., 1964, 112, 320-361.

Footnotes

1. This research was supported in part by Grants HD-00868, FR-00222 and FR-00537 from the National Institute of Mental Health, United States Public Health Service. The authors wish to thank Lynn Godfrey and Judy Lovett for data analysis.

2. Nine trials were presented. However, the present paper will only discuss the first five trials.

Table 1

Age Differences in Response to Repeated Stimuli: Linear Slope Function, Standard Error of Estimate, Trial 1 Minus 4 Differences for Both TF and FF as well as Trial 1 Minus 4 Differences Controlled for Initial Level (Sample 1)

| | Total Fixation Time | | | | | First Fixation Time | |
|---|---|---|---|---|---|---|---|
| Age | y = ax + b | SE | N | 1-4 | $\frac{1-4}{1}$ | 1-4 | $\frac{1-4}{1}$ |
| 3 Months | y = - .29 x +25 | 0.99 | 28 | 1.29 | .05 | 5.74 | .28 |
| 6 Months | y = - .67 x +19 | 0.82 | 20 | 2.36 | .15 | 1.43 | .14 |
| 9 Months | y = -1.48 x +19 | 1.14 | 31 | 4.83 | .29 | 3.79 | .38 |
| 13 Months | y = -2.58 x +28 | 1.12 | 29 | 7.70 | .36 | 8.25 | .55 |
| 18 Months | y = -1.81 x +24 | 1.35 | 14 | 6.23 | .22 | 3.86 | .66 |

Table 2

Age Differences in Response to Repeated Stimuli: Linear Slope Function, Standard Error of Estimate, Trial 1 Minus 4 Differences for Both TF and FF as well as Trial 1 Minus 4 Differences Controlled for Initial Level (Sample 2)

| | Total Fixation Time | | | | | First Fixation Time | |
|---|---|---|---|---|---|---|---|
| Age | y = ax + b | SE | N | 1-4 | $\frac{1-4}{1}$ | 1-4 | $\frac{1-4}{1}$ |
| 3 Months | y = - .98 x +28 | 0.36 | 20 | 2.73 | .10 | 8.06 | .33 |
| 6 Months | y = -2.03 x +27 | 1.36 | 20 | 5.30 | .22 | 10.71 | .58 |
| 9 Months | y = -2.37 x +21 | 1.48 | 20 | 5.43 | .27 | 9.43 | .64 |
| 13 Months | y = -1.51 x +22 | 1.99 | 20 | 3.53 | .16 | 6.23 | .36 |

Table 3

Age Differences in Response to Repeated Stimuli

For Both Fixation (TF and FF) and Cardiac Data

(Sample 3)

| | Total Fixation Time | | | | | First Fixation Time | |
|---|---|---|---|---|---|---|---|
| Age | y = ax + b | SE | N | 1-4 | (1-4)/1 | 1-4 | (1-4)/1 |
| 3 Months | y = .72 x +25 | 0.84 | 7 | -2.36 | -.09 | 2.20 | .08 |
| 6 Months | y = -1.72 x +25 | 3.12 | 7 | 4.68 | .22 | 2.00 | .22 |
| 9 Months | y = -1.73 x +21 | 2.68 | 6 | 7.37 | .38 | 7.20 | .51 |
| 13 Months | y = - .20 x +15 | 2.40 | 5 | .90 | .06 | 7.10 | .54 |

Cardiac Data

| Age | y = ax + b | SE | N | 1-4 | 2-4 |
|---|---|---|---|---|---|
| 3 Months | y = - .23 x +12 | 2.75 | 7 | .94 | 2.10 |
| 6 Months | y = -3.17 x +21 | 1.11 | 7 | 9.25 | 8.06 |
| 9 Months | y = -0.18 x + 8 | 2.09 | 6 | -.08 | 3.60 |
| 13 Months | y = 0.03 x + 9 | 3.85 | 5 | -1.62 | 5.72 |

Table 4

Age Differences in Cardiac Responsivity for

Each Repeated ($S_1$) and One Novel Trial ($S_2$)

(Sample 3)

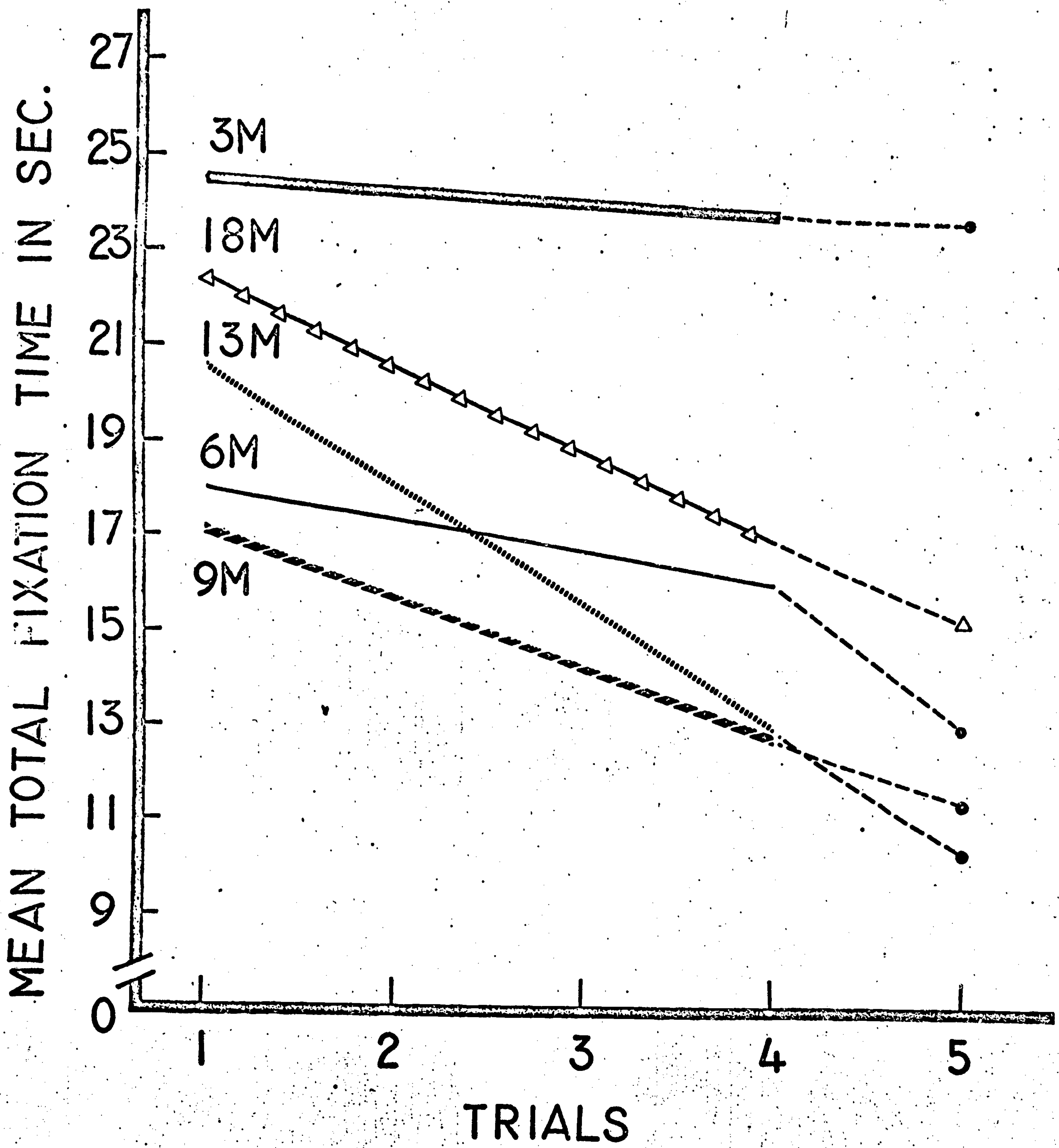
| | Trials | | | | |
|---|---|---|---|---|---|
| Age | 1 | 2 | 3 | 4 | 5 |
| 3 Months | -12.84 | -14.00 | -8.56 | -11.90 | -19.49 |
| 6 Months | -12.22 | -11.03 | -7.09 | - 2.97 | -12.79 |
| 9 Months | - 6.46 | -10.14 | -8.06 | - 6.54 | - 4.48 |
| 13 Months | - 1.60 | - 8.94 | -4.34 | - 3.22 | - 1.02 |

## Figure Captions

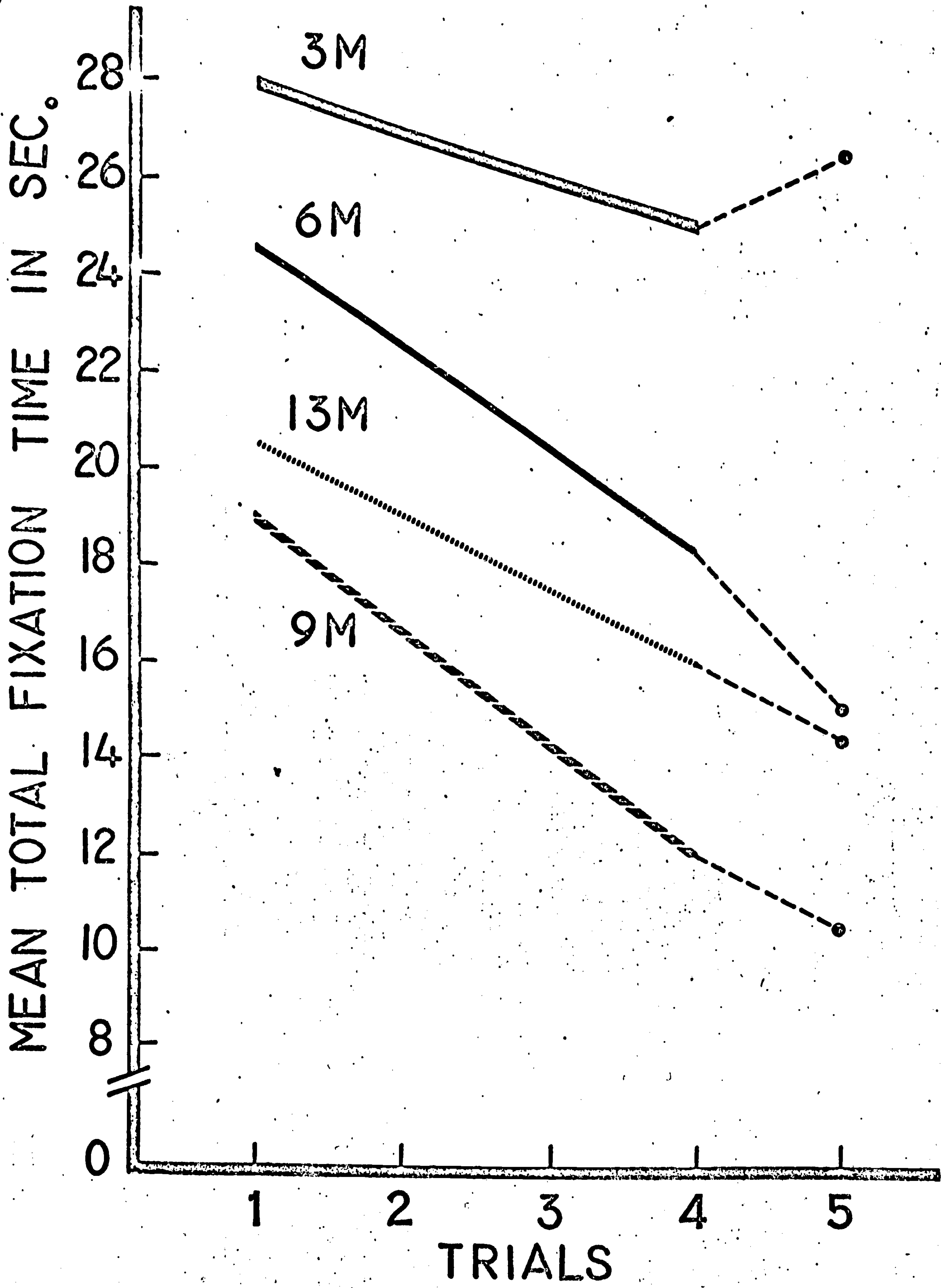
Figure 1. Best fit line for mean total fixation time across trials by age (Sample 1).

Figure 2. Best fit line for mean total fixation time across trials by age (Sample 2).

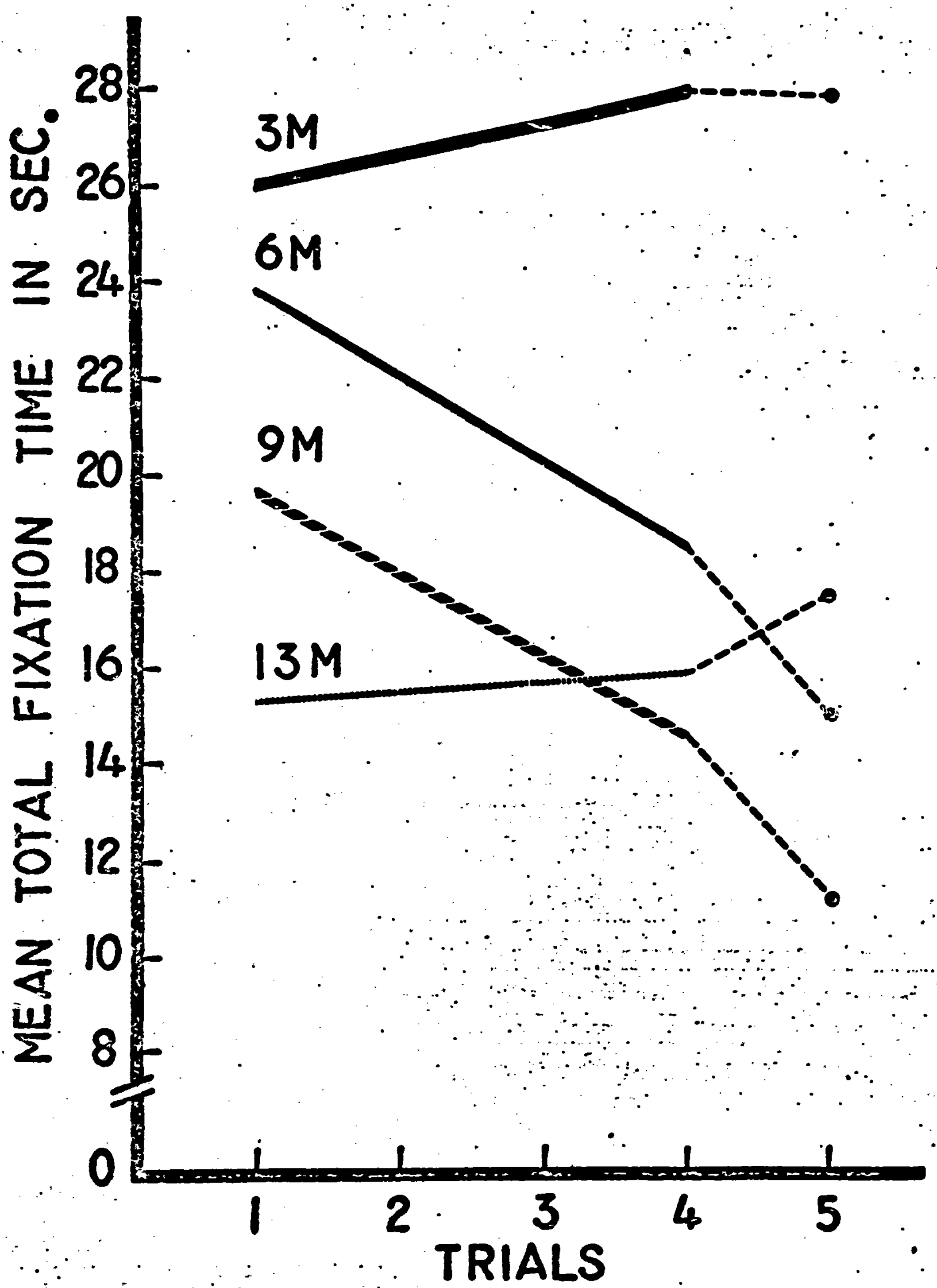
Figure 3. Best fit line for mean total fixation time and cardiac deceleration across trials by age (Sample 3).

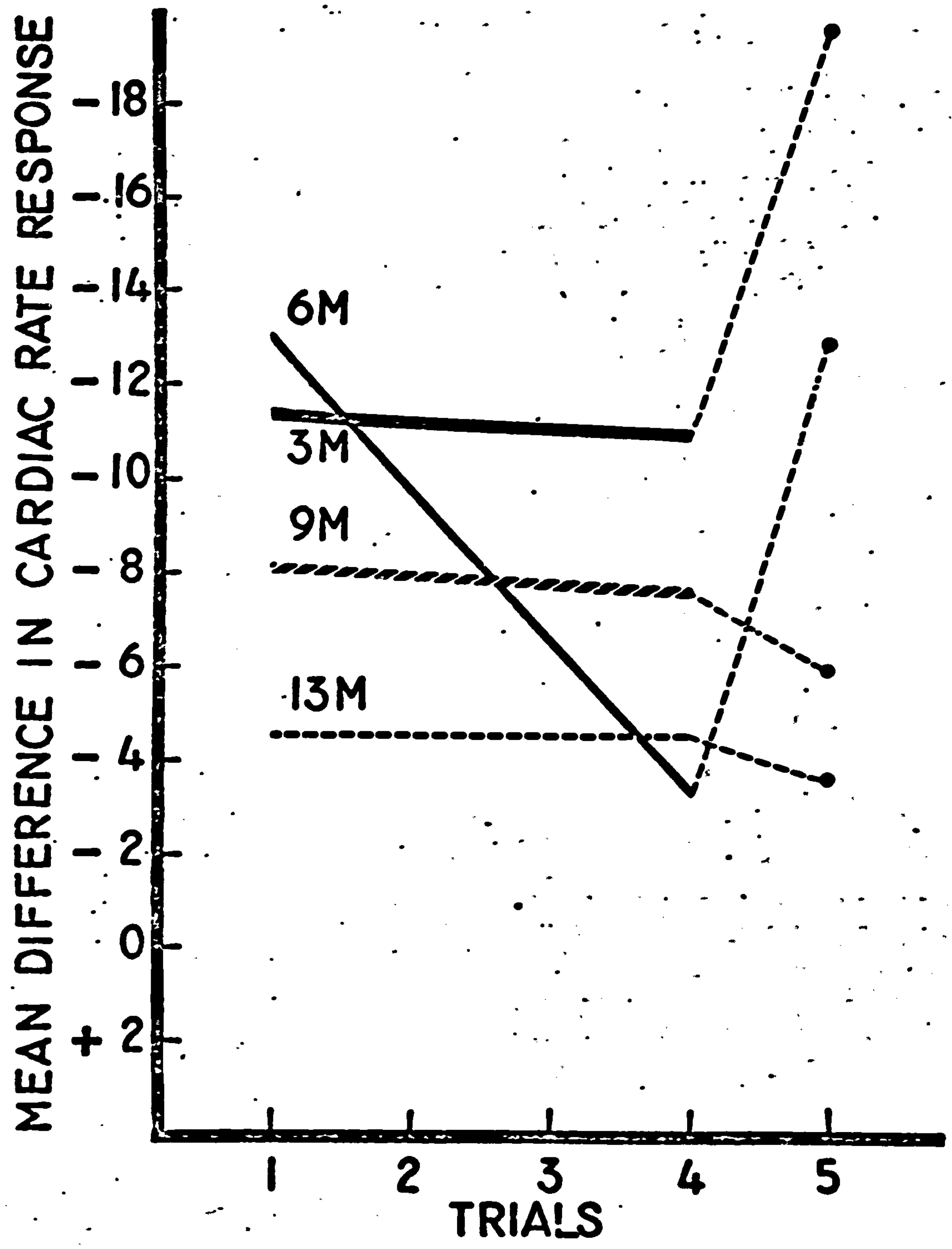


MEAN TOTAL FIXATION TIME IN SEC.
27
25
23
21
19
17
15
13
11
9
0
3M
18M
13M
6M
9M
1
2
3
4
5
TRIALS



MEAN TOTAL FIXATION TIME IN SEC.
28
26
24
22
20
18
16
14
12
10
8
0
3M
6M
13M
9M
1
2
3
4
5
TRIALS


MEAN TOTAL FIXATION TIME IN SEC.
28
26
24
22
20
18
16
14
12
10
8
0
3M
6M
9M
13M
1
2
3
4
5
TRIALS


MEAN DIFFERENCE IN CARDIAC RATE RESPONSE
-18
-16
-14
-12
-10
-8
-6
-4
-2
0
+2
6M
3M
9M
13M
1
2
3
4
5
TRIALS