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A COMPARATIVE ANALYSIS OF THE INFORMATION PROCESSING RATE OF THE DECISION MECHANISM OF RETARDATES AND NORMALS

by

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ABSTRACT

Eight male retarded Ss and eight male normal Ss took part in a choice reaction time experiment involving four levels of information load. The experiment required Ss to choose between two, four and six alternatives, depending on the condition being tested, and to respond by pressing the correct response button for each trial. Simple reaction time of both groups was also tested. The results obtained from the choice conditions of the experiment were tested by an analysis of variance test and a t-test was used to test the difference in simple reaction time between the two groups. The results indicated that there was a significant difference between the simple reaction of the two groups and that as information load was increased there was a significant increase in the difference in reaction time between the two groups. Also differences were found between the group variability and intra-individual variability of the two groups. The results were discussed in relation to information theory and other studies which have dealt with the reaction time differences of normals and retardates. It was concluded that retarded Ss have a slower simple reaction time than normal Ss, and that retardates process information in their decision mechanism, at a slower rate than normals. The decision mechanism

of retarded Ss was cited a partial source of the delay in reaction time of retarded Ss. It was felt that further investigation is necessary to determine to what degree the decision mechanism is responsible for the slower than normal reaction times of retarded Ss.

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CHAPTER 1

STATEMENT OF THE PROBLEM

Introduction

In studying the human organism it has been found that there is a finite elapse of time between the presentation of a stimulus and the initiation of a response. This characteristic of human behavior is known as reaction time (RT). To help understand the process underlying RT, models of human performance have been used to break it down into its component processes. Welford (1965; 1968), has suggested a model which looks at behavior in terms of three central mechanisms; a perceptual mechanism which organizes and classifies incoming information; a decision mechanism which selects the appropriate response; and an effector mechanism which organizes and executes the response.

Several studies, which have compared the RT of normals with that of retardates, have found a number of differences in RT between these two populations (Berkson 1960a, 1960b, 1960c; Berkson and Baumeister, 1967; Baumeister and Kellas, 1968; Jones and Hinkle, 1970). Berkson and Baumeister (1967) found that retarded subjects were generally slower in RT than normals and that the

retarded subjects were more variable both between and within subjects. Baumeister and Kellas (1968) also found retardates to have slower than normal RTs. Their results showed that the distribution of the retardates' responses tended to be more variable, platykurtic and symmetric, while the normals demonstrated typical leptokurtic distributions, skewed to the right (Figure 1). Jones and Hinkle (1970), provided further confirmation of both the Baumeister and Berkson (1967) and the Baumeister and Kellas (1968) studies, with their finding that the RTs of retardates were significantly more variable than the RTs of normals and that retardates had a slower RT than normals on both simple and choice RT tasks.

The finding of differences in RT between retardates and normals has prompted researchers to study each of the component processes of performance in an attempt to determine which of these processes is causing the slower than normal RT in retardates. Urquhart, Beedle and Smith (1964) looked at the perceptual component of RT by studying the effect of stimulus intensity on retardates and normals. They concluded that retardates were relatively more susceptible to decreases in the intensity of the RT stimulus than normals. Contrary to these findings Berkson (1960a) found that there was no difference in the duration threshold and consequently speed of perception of retardates and normals.

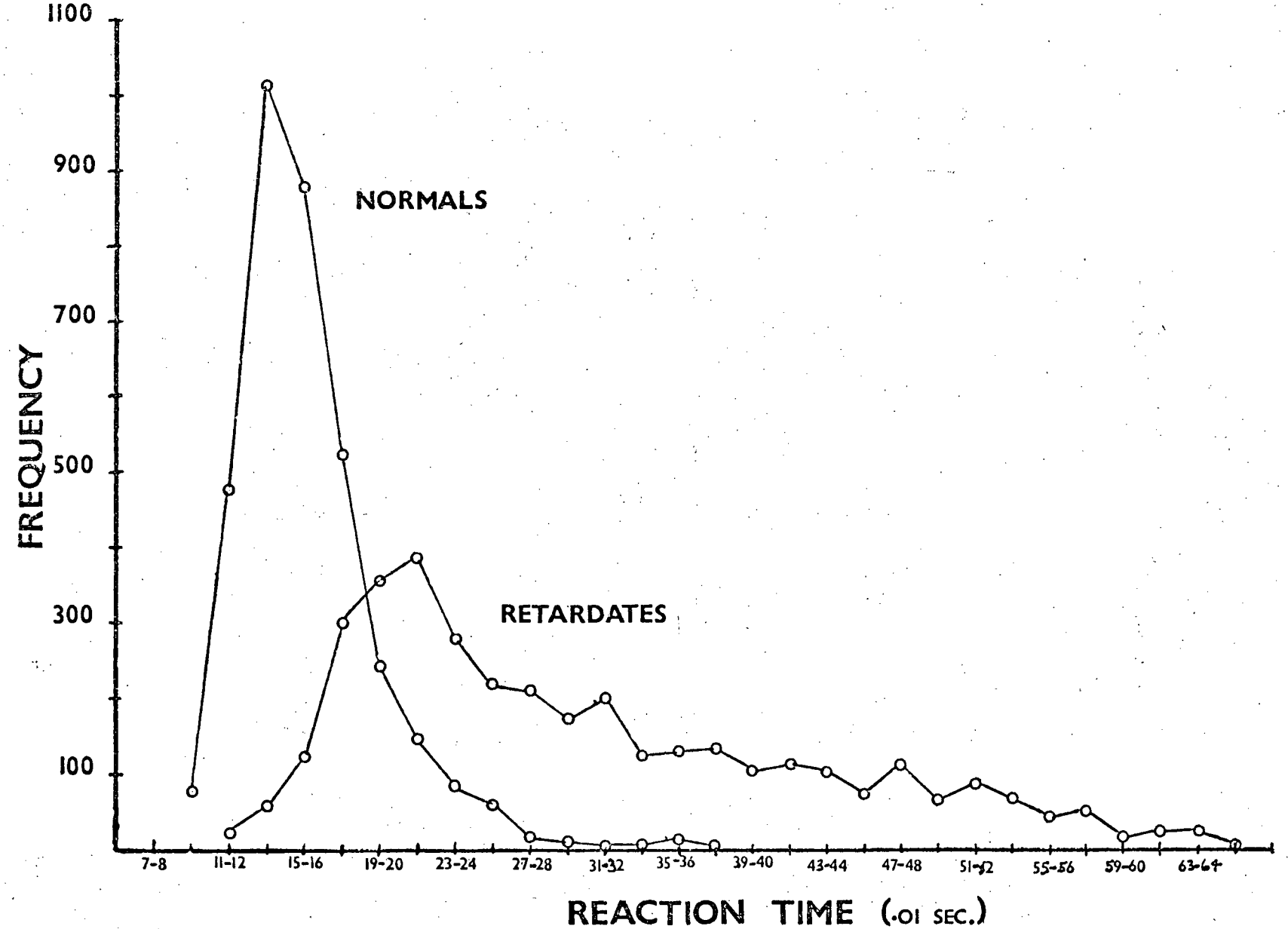

FIGURE 1: FREQUENCY POLYGONS OF RTs FOR NORMALS AND RETARDATES. (BAUMEISTER AND KELLAS 1968)

Other studies were designed to determine if the effector mechanism was causing the delay in the RT of retardates. An example of research done along this line is a study by Groden (1969), which found that the relationship between RT and mental age (r = .71) was eliminated when the complex perceptual-motor tasks (multiple key press tasks), were held constant but not when the simple skills (finger strength measured by a Lafayette dynamometer and finger oscillation), were held constant. From this he concluded that the complex skills involved something over and above what was required in the performance of a simple skill.

John Annett (1957) looked at the decision mechanism as a possible source of the delay in RT in retardates. He found a significant difference in the information processing rate of the decision mechanism (the time taken by the S to choose a correct response to match incoming information) of retardates depending on their level of retardation. He found that moderately retarded Ss process information faster than severely retarded Ss. Berkson (1960c) did a study in which he found no difference in the informational processing rate, of the decision mechanism, of retardates and normals. However, a number of faults were evident in the design of Berkson's study, as later pointed out in a study by Hawkins, Baumeister, Koenigsknecht and Kellas (1965).

In 1952 Hick developed a method of measuring the

rate of information processing of the decision mechanism in bits/seconds after refining the earlier work of Merkel (1885). He found that in a choice reaction time (CRT) experiment with an increasing number of alternatives, RT increased linearly as information load was increased. Further, he postulated that the reciprocal of the slope of this line represented the rate of information processing in bits/seconds. This method of determining the rate of information processing of the decision mechanism is dependent on the assumption that in a CRT experiment the roles of the perceptual and effector mechanisms are minimized. This assumption is known to be correct in relation to the effector mechanism since the motor response involved in a CRT experiment is usually a very simple key press task. However, it is questionable whether the role of the perceptual mechanism is truly minimized, since there is a slight increase in the size of the perceptual field in a CRT experiment. Fortunately, a study by Hyman (1953) has proven that the role of the perceptual mechanism is definitely minimized in the typical CRT experiment. Hyman used three different methods of placing an increasing informational load on his Ss. He increased the amount of information by; a) increasing the number of stimuli, b) by varying the probability of occurrence of each stimuli, and c) by varying the sequential probability of occurrence of the stimuli. He found that for all three methods the regression of RT on information was the same. Since the

last two methods, which didn't increase the perceptual field, produced the same effect as the first method, which did slightly increase the perceptual field, Hyman's study supports the viewpoint that a slight increase in number of stimuli doesn't increase perception time.

Purpose of Study

The purpose of this investigation is to compare the information processing ability of retardates and normals in terms of their ability to process information in a CRT experiment.

Hypotheses

1. That the simple RT of retarded Ss is slower than the simple RT of normal Ss.

2. That retarded Ss process information, in their decision mechanism, at a slower rate than normal Ss. This should be evidenced by retarded Ss displaying a slower CRT than normal Ss at a relatively low information input level with this difference becoming progressively larger as input information is increased.

It has been found by a number of studies that retarded Ss have a slower simple RT than normal Ss. Also, some of the literature reviewed in the present study has indicated that retardates possibly have a lower channel capacity, of the decision mechanism, than normal Ss. On

the basis of the literature reviewed, it is expected that the present study will show retarded Ss have a slower than normal simple RT and that retardates process information at a slower rate than normals.

Limitations

The conclusions of this study are limited to:

1. The sample size of eight Ss taken from each population.
2. The methods and procedures used in investigating the problem.

Delimitations

This investigation is delimited to the study of:

1. Normal right-handed males estimated by their teachers on the basis of classroom achievement to be of average intelligence (95-105 I.Q.), between 10 to 12 years of age, from McBride Elementary School, Vancouver.
2. Retarded right-handed males, estimated by their teachers on the basis of classroom achievement to be within the 45 to 54 I.Q. range, between 10 to 12 years of age, from Oakridge School, Vancouver.
3. The information processing rate of the decision mechanism in CRT.
4. The groups of Ss defined by their teachers' estimates to be within the 95-105 (normals) and the 45-54 (retardates) intelligence quotient range.

5. A description of human performance as hypothesized by Welford's model (1965; 1968).

Definition of Terms

Normals - have been operationally defined for the purpose of this study as those individuals estimated by their school teachers to be within the 95-105 I.Q. range.

Retardates - have been operationally defined for the purpose of this study as those individuals estimated by their school teachers to be within the 40-54 I.Q. range.

Informational Processing Rate - is the amount of transmitted information per response, divided by the time it takes to make the response. It is measured in bits per second. Information theory defines one "bit" of information as the amount of information needed to make a decision between two equally likely alternatives. The number of bits is computed by the following formula:

$$\text{"Bits"} = \log_2 N$$

where N equals the number of alternatives and where the alternatives were equally probable.

CHAPTER II

REVIEW OF LITERATURE

Differences in RT Between Normals and Retardates

In the last decade many differences have been found between the RTs of normals and retardates. The major difference that has been observed is that retardates, as a group, have significantly slower RTs than normals (Berkson, 1960a, 1960b, 1960c; Terrell and Ellis, 1964; and Jones and Hinkle, 1970). In addition to being slower than normals, Baumeister and Berkson (1967) found that the RTs of retardates are much more variable between and within Ss, than those of normals. Also, Baumeister and Kellas (1968) found that the distribution of retardate responses are platykurtic and symmetric, while normals display leptokurtic distributions skewed to the right.

The studies that have been reviewed in this investigation have all used moderately retarded subjects unless otherwise stated. However over the last three decades, in which most of the literature reviewed has been done, the definition of moderately retarded has varied greatly. Because of this it is recognized by the investigator that some of the discrepancies of results between studies may be partially due to differences in I.Q. levels. The presently accepted range of moderate retardation is between 40 and 54 I.Q. points.

Relationship Between RT and Intelligence

Since a difference in RT has been found between retarded and normal Ss, it has been hypothesized by some researchers

that there may be a strong relationship between intelligence and RT. Ellis and Sloan (1957) did a study entitled "Relationship Between Intelligence and Simple RT in Mental Defectives". In this study they found a negative correlation of -.54, between RT and mental ability. This correlation was significant beyond the .01 level of confidence. A negative relationship was also found by Bensberg and Cantor (1957) and by Dingman and Silverstein (1964). Dingman and Silverstein obtained a negative correlation of -.155, which was significant at the .05 level of confidence but not at the .01 level. Although these correlations reached the .01 and .05 levels of confidence, respectively, they are still very low correlations, and do not indicate a strong relationship between RT and intelligence. When these correlations are interpreted in terms of explained and unexplained variance (i.e. $r^2 \times 100$), it becomes apparent that differences in RTs only account for 25% and 2.5% respectively, of the variance in intelligence. On the basis of this closer analysis it must be concluded that RT cannot accurately predict a person's mental ability. However, these studies, which have attempted to relate RT and intelligence have shown that there is some relationship between these two variables, and has led researchers to wonder, which of the processes involved in RT is causing the discrepancy in RT between normals and retardates.

A Model of Human Motor Response

Welford (1965; 1968) suggested a model of human performance which outlines the processes involved in the

initiation and execution of a response. Welford feels that in order for information to be meaningfully exchanged from the environment to an individual's behavioral responses, it must pass through a chain of mechanisms which he has termed the perceptual mechanism (P.M.), the decision mechanism (D.M.), and the effector mechanism (E.M.). The sequential organization of these mechanisms is shown in Figure 2 below.

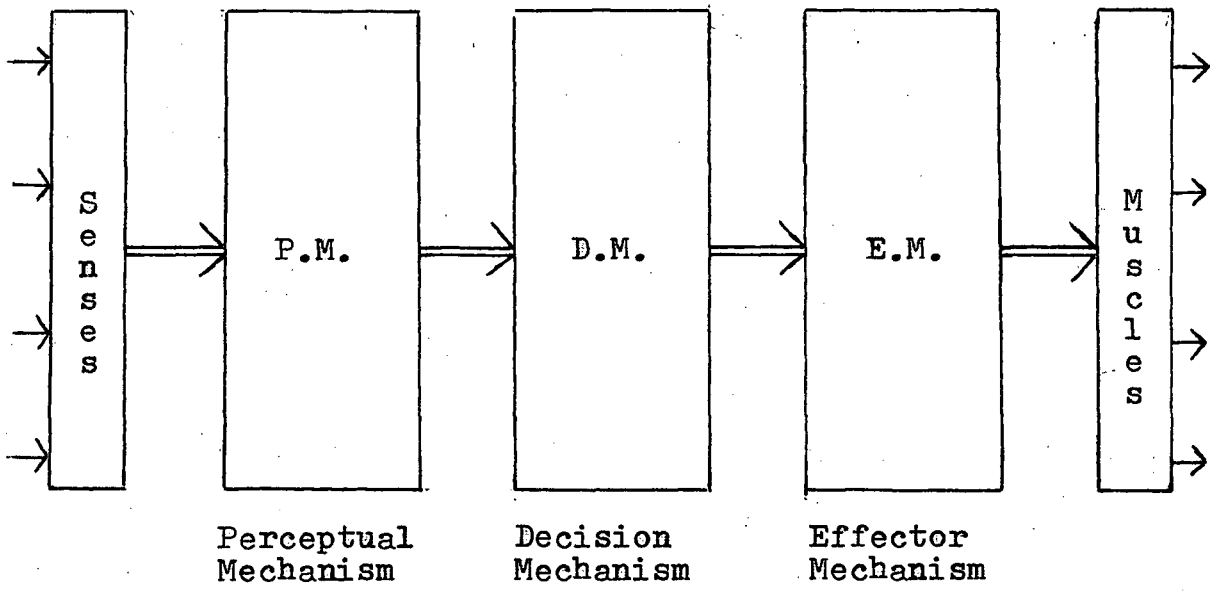

Figure 2: The Central Mechanisms as described by Welford's (1965) Model of Human Behavior.

The P.M. is responsible for perceiving external stimulation and encoding this information into a usable form. The D.M. receives information from the P.M. in the form of an information signal and is responsible for

selecting and calling-out from the E.M. the appropriate response to match the incoming information. Once the D.M. has selected and retrieved the appropriate response the E.M. receives an information signal informing it of the decision. The E.M. is then responsible for controlling the response throughout its execution.

The Perceptual Mechanism - Suggested Source of the Delay in RT of Retardates

Some researchers have suggested that the difference in RT of normals and retardates is caused by deficiencies in the P.M. of retardates. Baumeister, Urquhart, Beedle and Smith (1964), hypothesized that,

> "The differential reactions of these two groups are partly a function of the intensity of the stimulus to respond, and further, that decreases in intensity are more deleterious to the performance of the defective subjects."

This study showed that the predicted Intelligence Groups by Stimulus Condition interaction was significant at the .05 level. From this Baumeister et al concluded that,

> "it tends to support the hypothesis that retardates are relatively more susceptible to decreases in the RT stimulus than normals".

However, many weaknesses can be found in the design of this study. Baumeister et al failed to control for threshold difference between the two populations, and used a constant preparatory interval. A second study was done by Baumeister, Hawkins and Kellas (1965), in order to correct these faults. This study also found a significant interaction (Intelligence

by Stimulus Condition), and therefore Baumeister et al concluded that the difference in RT of retardates and normals is somewhat caused by deficiencies in the P.M. of retardates.

Although a significant interaction was found (.05 level) it is noted by the author that the decrease in the mean RT of the retarded Ss for the three different preparatory intervals, at the greatest intensity level, was only 50 milliseconds more than the mean decrease of the normal Ss. The results of this study are shown in Table 1 below.

TABLE 1

MEAN RT FOR NORMALS AND RETARDATES UNDER VARIOUS CONDITIONS OF INTENSITY AND WARNING

Group	Intensity								
	25 db P.I.			50 db P.I.			75 db P.I.		
	4 sec	5 sec	6 sec	4 sec	5 sec	6 sec	4 sec	5 sec	6 sec
Normals	.311	.290	.300	.279	.276	.268	.247	.244	.238
Retard-ates	.470	.459	.462	.422	.415	.422	.360	.349	.361

Also, it is felt by the author that differences in the perceptual capacities of retardates and normals explain only a small portion of the difference in RT of these two groups

since the RT of the retardated group, at the highest intensity level, was still 122 2/3 milliseconds slower than the RT of the normal group.

Contrary to the findings of Baumeister et al (1964; 1965), Berkson (1960a) found that there was no difference in the duration thresholds, and consequently speeds of perception, of retardates and normals, and thus concluded that intelligence isn't related to speed of perception. Berkson used a t-test to compare the mean duration thresholds of the retarded and normal groups. He found no significant mean difference at the .05 level of confidence.

Research by Goldiamond in 1960, also showed no significant threshold difference between retardates and normals. However, contrary to both Berkson's and Goldiamond's studies, and congruent with earlier studies by Baumeister et al (1964; 1965), Spitz (1967) found that retardates, as a group, had a lower channel capacity in their perceptual mechanisms than did normals subjects. Spitz tested three groups of Ss; retardates, and equal mental age and equal chronological age normals, on an absolute judgement task in which they were required to judge a position of a pointer on a horizontal line. After each judgement they received feedback from a previously hidden scale. Spitz found that the channel capacities of the three groups were 2.68, 3.13 and 3.43 bits, respectively. A later study by Spitz (1969) also showed that retardates were more negatively effected by reduction of stimulus information in a visual search task, than were normal Ss of

the same age. Spitz used three groups of subjects; adolescent retardates and fourth and seventh grade normals. In analyzing the results of the three groups Spitz found that the loss of information had an equally negative effect on the retardates and the fourth graders, but it had a much lesser effect on the seventh grade group. Spitz applied Neisser's (1967) two-level hypothesis of mechanisms used in visual search, to his results and concluded that the retardates and fourth graders were having difficulties in the pre-attentive phase (organism scans the material), rather than in the focal attention phase (organism concentrates on and analyzes the chosen object). Spitz concluded that as non-retarded people mature they develop additional resources at the pre-attentive stage of alertness. He felt that these resources are lacking in retarded Ss.

A recent study by Patricia L. Austin (1969) found evidence which lends support to Spitz's (1967) findings. Austin found that the difference in RT between normals and retardates was greatly increased as the complexity of the perceptual task increased. These results are shown in Figure 3. Austin concluded that Educably Mentally Retarded (E.M.R.) Ss process information, in their perceptual mechanism, at a slower rate than normals. However, it is felt by the author, that the results of this study are confounded since the complexity of the task was increased by increasing both the number of stimulus alternatives and possible re-

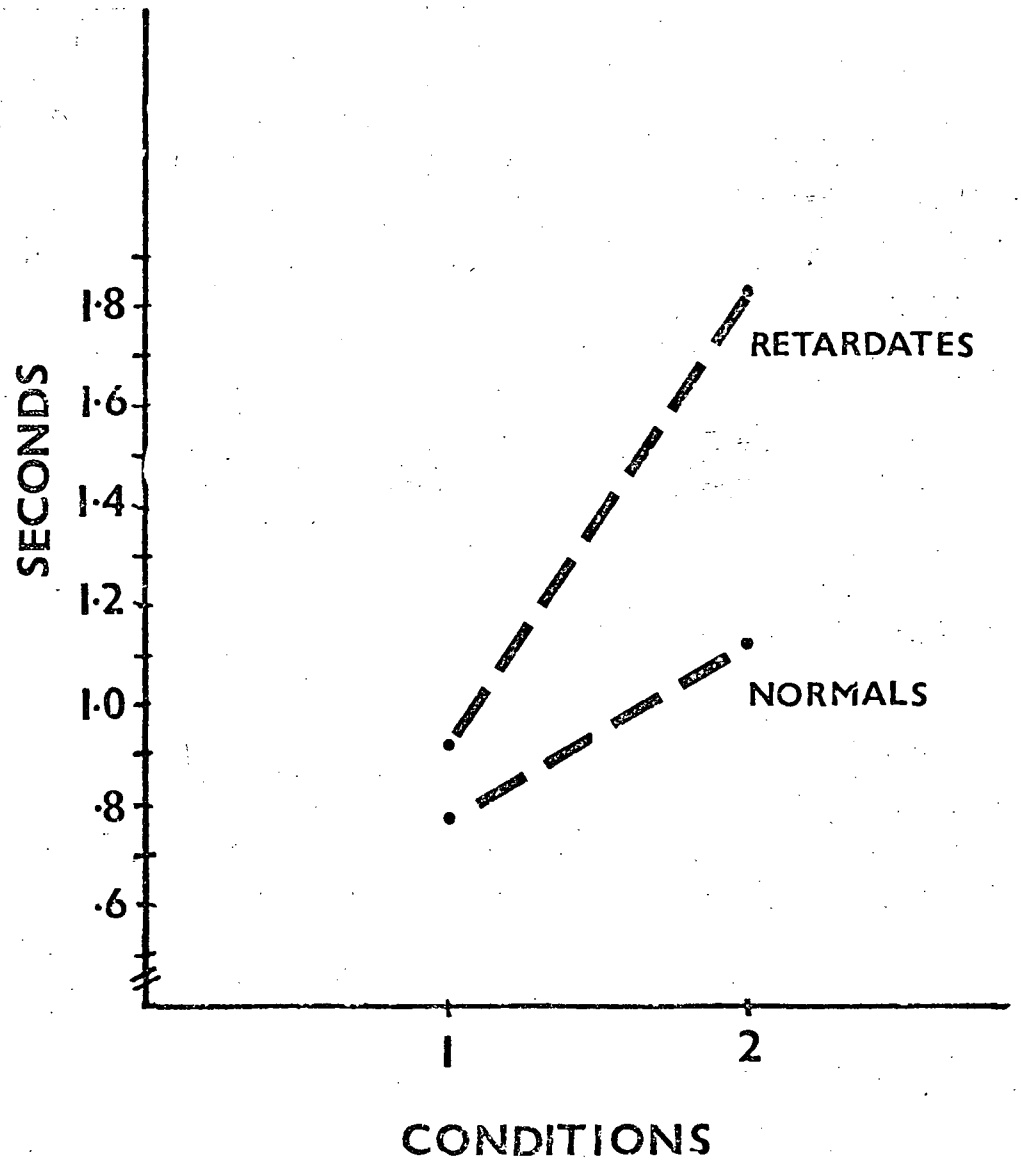

FIGURE 3: RTs OF E.M.R. AND NORMAL Ss ON A GROSS MOTOR-PERCEPTUAL TIME TASK (AUSTIN 1969).

sponses, and by increasing the complexity of the stimulus patterns. It is felt that the results do not clearly indicate whether the delay in information processing, demonstrated by the retardates, is occurring in the perceptual mechanism or the decision mechanisms. Also it is the opinion of the author, that the results of Austin's study were further confounded by the fact that as complexity was increased in the second condition, stimulus response compatibility was greatly decreased. Therefore, the author feels it is impossible to conclude whether the retardates are processing information of a perceptual nature, at a slower rate or whether their rate of learning is slower.

Effector Mechanism - Suggested Source of Delay in RT of Retardates

Compared to the amount of research that has been done on the P.M., very little research has been done in which the E.M. has been studied as the possible cause of the slow RTs manifested by retardates. Two recent studies have indirectly looked at the E.M. by trying to correlate intelligence with motor ability of retardates. Dingman and Silverstein (1964) measured 265 retardates on RT and two tests of motor ability (tapping and steadiness). They found that when the effects of tapping and steadiness were held constant the significant correlation between intelligence and reaction time, which they had obtained, disappeared. And when intelligence and steadiness were held constant the

significant correlation between reaction time and tapping still remained.

A later study by Knights, Atkinson and Hyman (1967) found contrary to Dingman and Silverstein, that holding tapping constant did not significantly affect the correlation found between intelligence and RT. However, it was noted by Groden (1969) that the tapping tasks used by Dingman and Silverstein, and Knights, Atkinson and Hyman were quite different. The task used by the former authors required quite a bit more perceptual motor co-ordination than the one used by the latter authors. With this in mind Groden designed a study in which he included both a simple and a complex motor task. He found that the relationship between reaction time and mental age ($r = -.710$) was eliminated when the complex, but not the simple, motor skills were held constant. From his results Groden concluded:

> "Apparently it is not simple motor ability which may be fundamental to the relationship between intelligence and reaction time since removal of effects of motor strength, finger oscillation and motor abilities did not cause the relationship to disappear. In other words, motor ability per se, seems to be irrelevant. Both reaction time and complex, perceptual-motor task, key press, require something over and above what is required by such simple motor tasks as motor strength and finger oscillation."

The Decision Mechanism - Suggested Source of Delay in RT of Retardates

A few researchers have regarded the functioning of the perceptual and effector mechanisms secondary, and instead looked towards the decision mechanism as the cause of the discrepancy in the RTs of normals and retardates. In 1957 John Annett did a study entitled "The Information Capacity of Young Mental Defectives in an Assembly Task". Annett used three levels of retardates, low, mid and high grade, as his Ss. He had them perform an assembly task made up of four sub-components: reach, grasp, carry and assemble. Reaction time was measured as the time taken to perform the first component (i.e. contact the peg). The informational load was increased from one to three bits of information. An analysis of variance on the pooled scores of the low, mid and high grades showed that the effect of the informational load was significant and the slopes of the graphed information processing lines of the three groups were significantly different.

It is noted by the author that the task used in Annett's study did not minimize the role of the perceptual and effector mechanisms. In fact a great deal of perceptual and motor ability was involved in the task, but these were held constant while the information load was increased, and therefore it is questionable whether or not this affected the validity of the results.

Berkson (1960c) did an interesting experiment in

which he varied separately in different conditions, the complexity of the stimulus and the complexity of the response. He found that there was no interaction between intelligence and task on conditions where stimulus complexity was increased, and therefore concluded that it wasn't a difference in the decision mechanism of these two intelligence groups that was producing the difference in RT. He did, however, find a significant interaction between task and intelligence group for the conditions in which response complexity was progressively increased. From these results he concluded that the difference in RT of retardates and normals is caused by the functions involved in the initiation of performance, (i.e. effector mechanism). However, it is important to note that it was later pointed out in a study by Hawkins, Baumeister, Koenigsknecht and Kellas (1965) that,

> "One of the difficulties with Berkson's studies was the confounding of the type of response with complexity of the discrimination. The response required in simple reaction time was not the same as that employed in the disjunctive task."

With the faults of Berkson's study in mind, Hawkins, Baumeister, Koenigsknecht, and Kellas (1965) designed a study to again look at the differences or similarities of the decision mechanism of normals and retardates. They increased the complexity of the response stimulus from one to two stimulus lights. Contrary to their hypothesis there wasn't a significant interaction between intelligence groups and complexity. It is felt by the author that a

significant interaction wasn't found since the increase in complexity, from one to two stimulus lights, wasn't large enough to produce differentiation in the rate of information processing of retardates and normals.

In conclusion, a review of the literature to date studying the slower than normal RTs of retardates, shows conflicting and incomplete results. It points to a need for further research in this area in order to determine which component process of RT is the cause of the slower than normal RT of retardates. More specifically it points to a need for a test of the decision mechanism since it is felt that to date there hasn't been an adequate test of the decision mechanism in relation to the delay in RT of retarded subjects.

The literature strongly suggests that the delay in RT of retardates could be caused by deficiencies in all three of the component processes of human behavior. Each of the three processes have been implicated by evidence found in different studies. However, it is felt by the author, important that each of these mechanisms be studied separately in relation to the delay RT of retardates, so that the results are not confounded and that a clear picture regarding the RT of retarded subjects will eventually emerge.

CHAPTER III

METHODS AND PROCEDURES

Subjects

Eight right-handed males, 10 to 12 years of age, estimated by their school teachers to be within the 95-105 I.Q. range, from McBride School, were used as representatives of the normal population.

Eight right-handed males, 10 to 12 years of age, estimated by their school teachers to be within the 40-54 I.Q. range, from Oakridge School, were used as representatives of the mentally retarded population. No subjects with a medical history of organic brain damage were included in this group.

Apparatus

The apparatus used in this experiment, which is shown in Figure 4, consisted of two arrays of red stimulus lights (four in each array) and two corresponding arrays of black response buttons, (four in each array). The stimulus lights were each half an inch in diameter and arranged in a straight line parallel to the table top, with half an inch between each light. There was a distance of one and a half inches between the two stimulus light arrays, and in the middle of this space, half an inch lower

1 — CONTROL BOX
2 — TIMER
3 — CARDBOARD WALL
4 — STIMULUS COVERS
5 — STIMULUS LIGHTS
6 — WARNING LIGHT
7 — RESPONSE BUTTONS

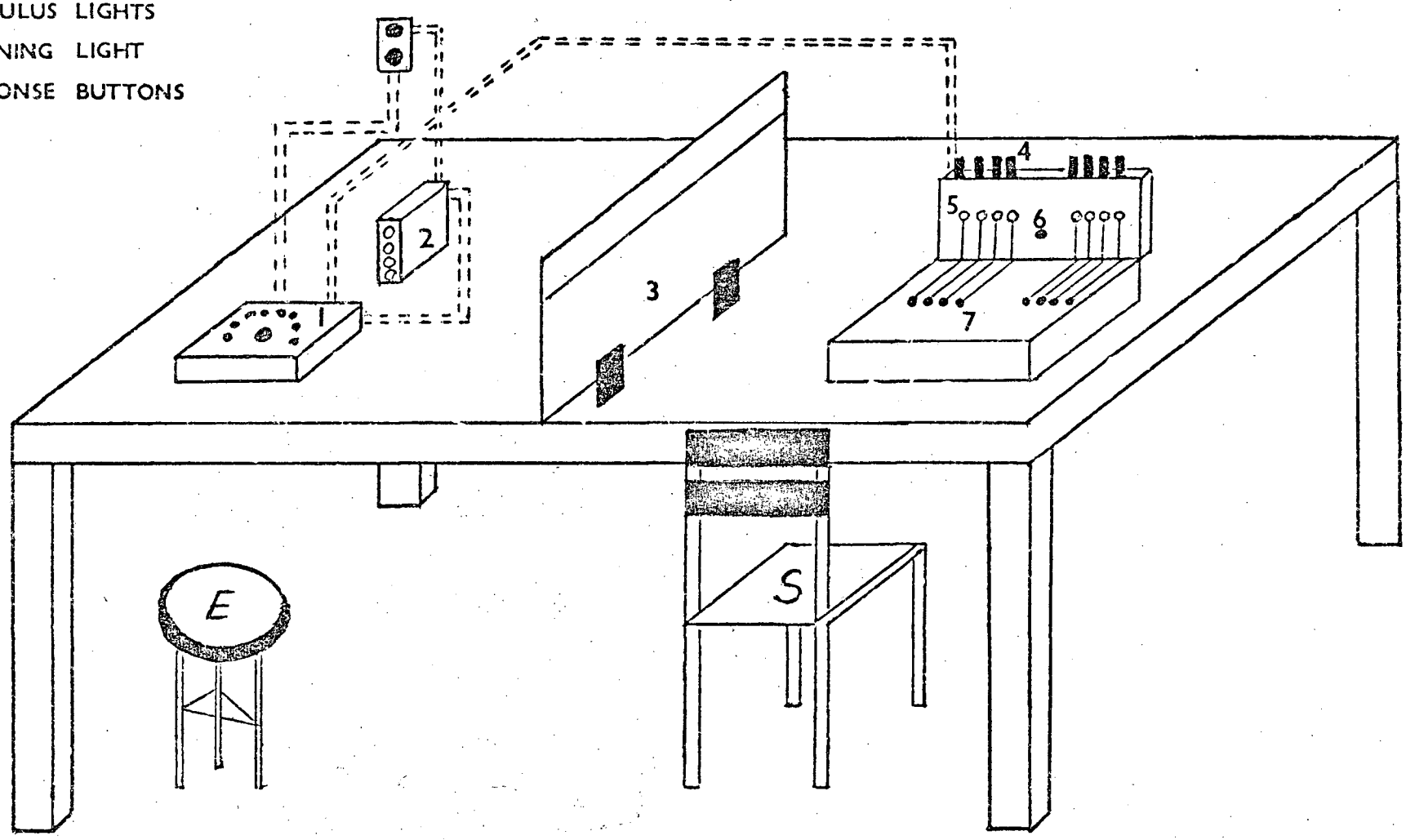

FIGURE 4: APPARATUS AND POSITION OF SUBJECT AND EXPERIMENTER AT APPARATUS.

than the stimulus arrays, was situated a yellow warning light, also half an inch in diameter. The response buttons, which were arranged in a slight arch, were situated below and forward from the stimulus lights. The two outside buttons in each array were one and three-quarter inches forward from the stimulus light, while the two inside buttons were one and a half inches forward. The panel on which the response buttons were mounted was one inch below the height of the stimulus lights. The response buttons were a quarter of an inch in diameter with half an inch between each button. The arrays were arranged so that there was two and a half inches between arrays and the arrays were seven and a half inches from the front edge of the apparatus. The size and positioning of the response keys was designed to be suitable for the hand size of young children.

The apparatus basically followed the standard design of button press apparatus used in CRT experiments. Three modifications were made from the standard design. As was already mentioned, the dimensions of the response buttons were modified in order to suit the hand size of young children. Also strips of white tape (1/8 inch wide) were run from each stimulus light to its corresponding response button in order to increase the stimulus-response compatibility. This was done to assist the retarded Ss in understanding the experimental task. A final modification was the hinging of metal plates above each of the stimulus

lights, so that when any of the stimulus lights weren't being used for a certain experimental condition they could be covered up by simply dropping the appropriate metal plates over them. This was done to make the experimental task less confusing for the young retarded and normal subjects.

Position of Subject (S) and Experimenter (E) at Apparatus. The S sat directly in front of the experimental apparatus (Figure 4) so that when both hands were on the key-board the subject's arms were parallel to each other and perpendicular to the front edge of the apparatus. The height of the chair was adjusted to insure that the forearm of each S was parallel with the floor when his hands were placed on the keyboard. Each S was permitted to adjust the distance of the chair from the table to a comfortable position.

The experimental apparatus was placed on the table with the front edge one inch from the edge of the table. Six inches to the left of the experimental apparatus a cardboard partition, two feet by two feet, was placed perpendicular to the edge of the table and extended two inches over the edge of the table. This partition was placed so that the subject could not view the timer or control apparatus when seated in front of the experimental apparatus. To the left of the cardboard partition was the control apparatus and timer which was situated as far as possible (five feet five inches) from the experimental apparatus so

the S would not receive auditory cues from the noise of the electrical circuits. The E sat directly in front of the timer and control apparatus at a comfortable distance from the table where she could view the S.

Experimental Design

The present study was a two by four factorial experiment with repeated measures on one factor. Also a Latin square was used in order to control for a possible learning effect over the four CRT conditions. The experiment involved two different I.Q. levels represented by two groups of Ss. Each S was required to perform a CRT task under four different levels of information. Level or condition one was a test of simple RT with only one stimulus presented. Level two consisted of a choice between two alternatives or one bit of information. Level three and four respectively consisted of a choice between four and six alternatives. In terms of information theory four alternatives is equal to two bits of information and six alternatives equals two decimal five eight bits of information. Each subject was given 10 trials on Condition one, 20 trials on Condition two, 40 on Condition three and 60 on Condition four, for a total of 130 trials per subject. Since only the right index finger responses were recorded it was necessary to increase the number of trials as the number of alternatives were increased over conditions. By increasing the number of trials in proportion with the number of alternatives the prob-

ability of a right index finger response being required was kept constant over the four conditions.

Procedures

The experiment began with the S entering the testing room and being seated in front of the apparatus in the position previously described. The S was given a suitable period of time (approximately three to five minutes) to acquaint himself with the equipment. He was then asked to listen while the instructions (Appendix B) were read to him, interspersed with demonstrations. The instructions were designed to be easily understood by the retarded Ss and were tested and refined during a pilot study with two retarded Ss. Following the reading of the instructions the S was told to place his eight fingers (1st, 2nd, 3rd and 4th finger of each hand) on the appropriate response buttons in the manner described in the instructions. All eight fingers were rested on the response keys for all conditions. The S was then given five learning trials on the condition on which he was going to be tested. It was found from a previous pilot study (Appendix A), done by the author, that a minimum of five practice trials at each level was necessary in order for the S to clearly understand the task. On the basis of this information both groups (normals and retardates) were given five practice trials on each condition. On completion of the learning trials the experimental trials were administered. At the beginning of each trial E gave

the command "ready" and then presented the warning light. Two, three or four seconds later a particular stimulus light was presented, depending on the condition being run, and the S responded by pressing the proper response button as quickly as possible. The time of the preparatory interval and the presentation of the stimulus lights were randomly varied within each condition. A table of random numbers was used to determine the order of the stimuli and the preparatory intervals. The intertrial interval was approximately 10 seconds and encompassed the time required by E to record the S's response, to reset the clock and to place the control switch in position for the next trial.

During the experimental trials the S was observed very closely by E for signs of fatigue or declining interest. If it was deemed necessary by E the S was given a rest of five minutes. Following the rest period the S was given three practice trials before the experiment was continued. It was found in a previous pilot study (Appendix A) that it was possible to run both Conditions 1 and 2 in the same testing session, when they fell in that order, but that 3 and 4 had to be tested separately since they were much longer and the retardates tended to fatigue quite quickly.

Analysis of Data

The time from when the stimulus light was presented to when the S pressed the response key was recorded as RT. The recorded value for each condition was the mean of 10 RTs

of the right index finger. Since there were eight Ss in each group the mean RT for each condition, in each group, represented the mean of 80 trials.

The mean scores for each S, for each condition and in each group, were analyzed by an analysis of variance test in order to determine the effect of information on RT, and to compare this effect for the two groups. A trend analysis was performed on the conditions and groups by conditions effects which showed a significant F ratio, in order to see if a linear trend was occurring and if there was a difference in the slope of the trend between groups.

The difference in simple RT (Condition one) between the two groups was tested for significance by both a planned comparison analysis and a t-test. The t-test was used after the results of the planned comparison analysis failed to achieve significance, since it was felt that the error term used in the planned comparison analysis wasn't an accurate estimate of variance for comparison of the simple RTs. A further explanation of the reasons for using the t-test is presented in Chapter IV.

In order to look at the group variability the standard deviation of the S means was computed for each group. This value was then squared to show the group variance of each group. The intra-individual variability was determined by taking the standard deviation of the ten

right index response scores of each S, on each condition. These values were then squared to reveal the intra-individual variability of each S on each condition.

CHAPTER IV

RESULTS AND DISCUSSION

RESULTS

Difference Between Group RT Over All Four Conditions

It can be seen in Figure 5 that the retarded group was more detrimentally affected by increases in information load than the normal group. Figure 5 shows that with each increase in information (from Condition one through Condition four) the difference in RT between retardates and normals was increased. These results are also presented in Table 2 which shows the mean RT and variance of each group for each condition.

TABLE 2

MEAN RT AND VARIANCE OF RETARDATES AND NORMALS FOR CONDITIONS 1, 2, 3 AND 4

	Retardates		Normals	
	RT	Variance	RT	Variance
Condition 1	0.516	0.0329	0.205	0.0013
2	0.749	0.0247	0.355	0.0017
3	1.109	0.2367	0.431	0.0012
4	1.196	0.1376	0.463	0.0027

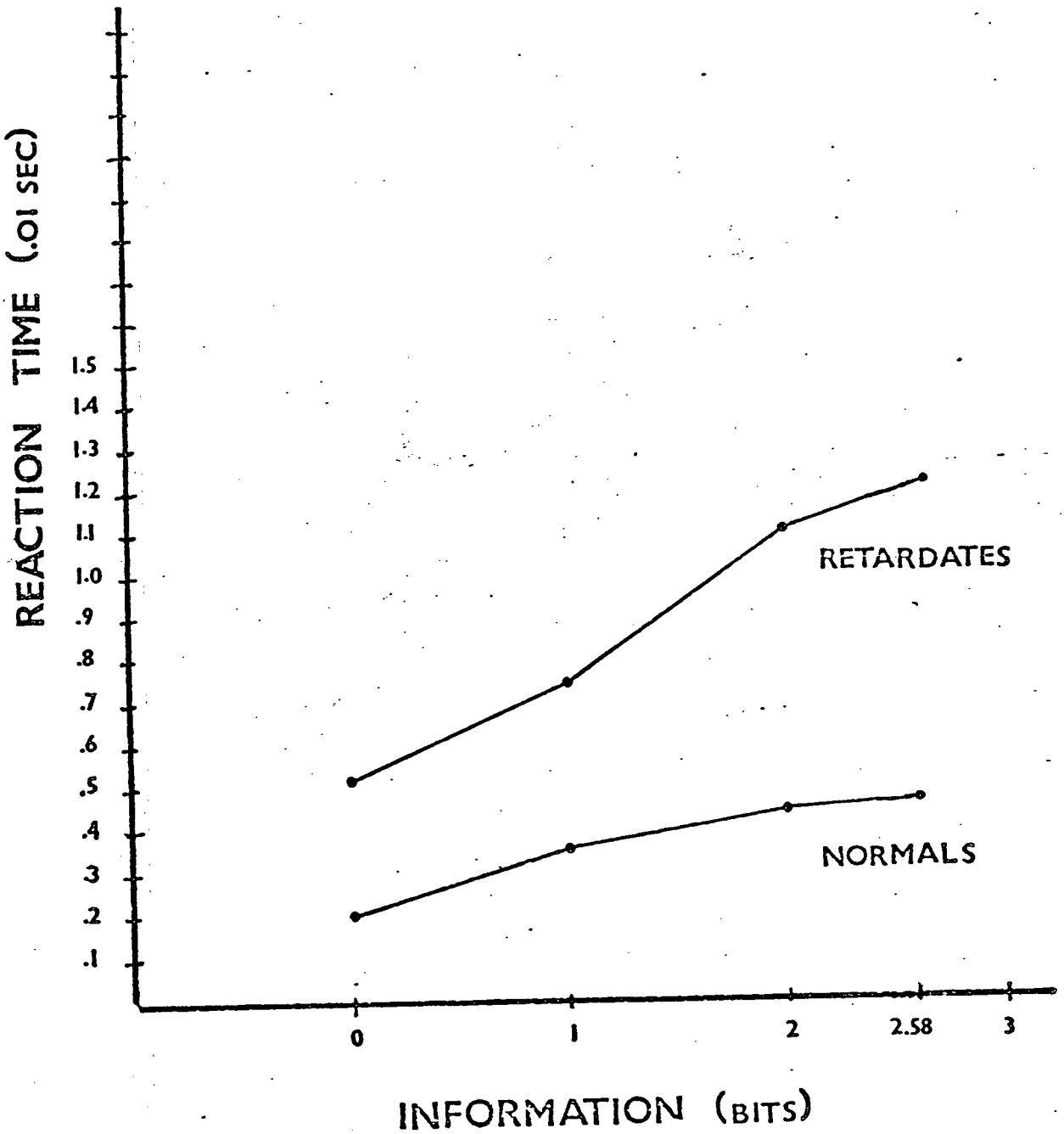

FIGURE 5: MEAN RT AS A FUNCTION OF INFORMATION LOAD

The results shown in Table 2 revealed a much larger degree of group variability within the retarded group than the normal group. It is recognized by the investigator that the large difference in group variances could possibly confound the analysis of the results, since homogeneity of variance must be assumed when using an analysis of variance test. However, it has been shown (Welch, 1937; David and Johnson, 1951b; Box, 1952; and Horsnell, 1953), that in the commonly occurring case, in which group sizes are equal, or near equal, the analysis of variance test is affected surprisingly little by unequal variances. Box (1953) recommends,

> "Since this test is also known to be very insensitive to non-normality it would be best to accept the fact that it can be used safely under most practical conditions."

The results shown in Figure 5 and Table 2 were analyzed by an analysis of variance test, the results of which are shown in Table 3.

It can be seen that the main effects of Groups, Conditions and Groups by Conditions interaction are significant at the .01 level of confidence. A trend analysis done on the Conditions effect revealed a significant linear trend (.01 level), and the same analysis on the Groups by Conditions interaction showed a significant linear x linear effect (.01 level).

In order to determine if the difference in simple RT of the two groups, which is shown in Table 2, was a

TABLE 3

ANALYSIS OF VARIANCE OF RT
OVER CONDITIONS 1, 2, 3 AND 4

Source of Variance	d.f.	M.S.	F	P
Groups	1	44.743	25.89	<.01
Subjects (Groups)	14	1.728		
Conditions	3	7.350	28.21	<.01
Linear	1	21.08	81.07	<.01
Quad.	1	0.697	2.68	>.10
Groups x Conditions	3	1.724	6.62	<.01
Linear x Linear	1	4.799	18.45	<.01
Linear x Quad.	1	0.008	0.03	>.25
Subjects (Groups) x Conditions	42	0.260		
Trials	9	0.114	2.33	
Groups x Trials	9	.075	1.53	
Subjects (Groups) x Trials	126	0.049		
Conditions x Trials	27	0.065	1.41	
Groups x Conditions x Trials	27	0.053	1.18	
Subjects (Groups) x Conditions x Trials	378	0.045		

significant difference a planned comparison was done on the results for Condition 1.

Using this analysis, the difference in simple RT between the normal and retarded group failed to reach a level of significance. In the planned comparison analysis the mean squares for the Subjects (Groups) by Conditions effect (0.260) was used as the error variance estimate. It was felt that this was not an accurate estimate of error variance when comparing the simple RT of the two groups, since it included the group variance for the CRT conditions. Table 2 shows that on Conditions three and four the variance of the retarded group greatly increased while, by comparison, the group variance of the normal group remained the same. It can be seen from Table 2 that the variance estimate is greatly inflated by including the variance of the CRT conditions. Thus for these reasons a simple t-test analysis was used to compare the two simple RT means with the error term used being calculated on the group variance for Condition one, the simple RT condition. With equal Ss and heterogeneity of variance, t was calculated in the usual manner, but the obtained value of t was evaluated in terms of the tabled value for half the number of degrees of freedom that would have been available with homogeneity of variance. The t-test analysis revealed a significant difference (.01 level) between the simple RT of the normal and retarded groups. The results of both the planned comparison analysis and the t-test are shown in Table 4.

TABLE 4

T-TEST AND PLANNED COMPARISON
ANALYSIS OF DIFFERENCE IN MEAN RT
FOR CONDITION 1

	t	P
Planned Comparison	1.22	$>.05$
t-test	5.18	$<.01$

Group Variability

While the group means of the retardates are significantly different from those of the normals, it has been found that the variance in the retarded group, on all four conditions, was much greater than that of the normals (Table 2).

It was also found that the variance of the normal group remained fairly consistent over the four conditions, while the variance of the retarded group greatly increased on Conditions three and four, the more complex conditions. The variance of both groups has also been shown graphically in Figure 6.

It was also discovered that while the retardate group was very variable, there was negligible overlap between the scores of the two groups. All but one of the retardates scores was higher than the scores of the normal

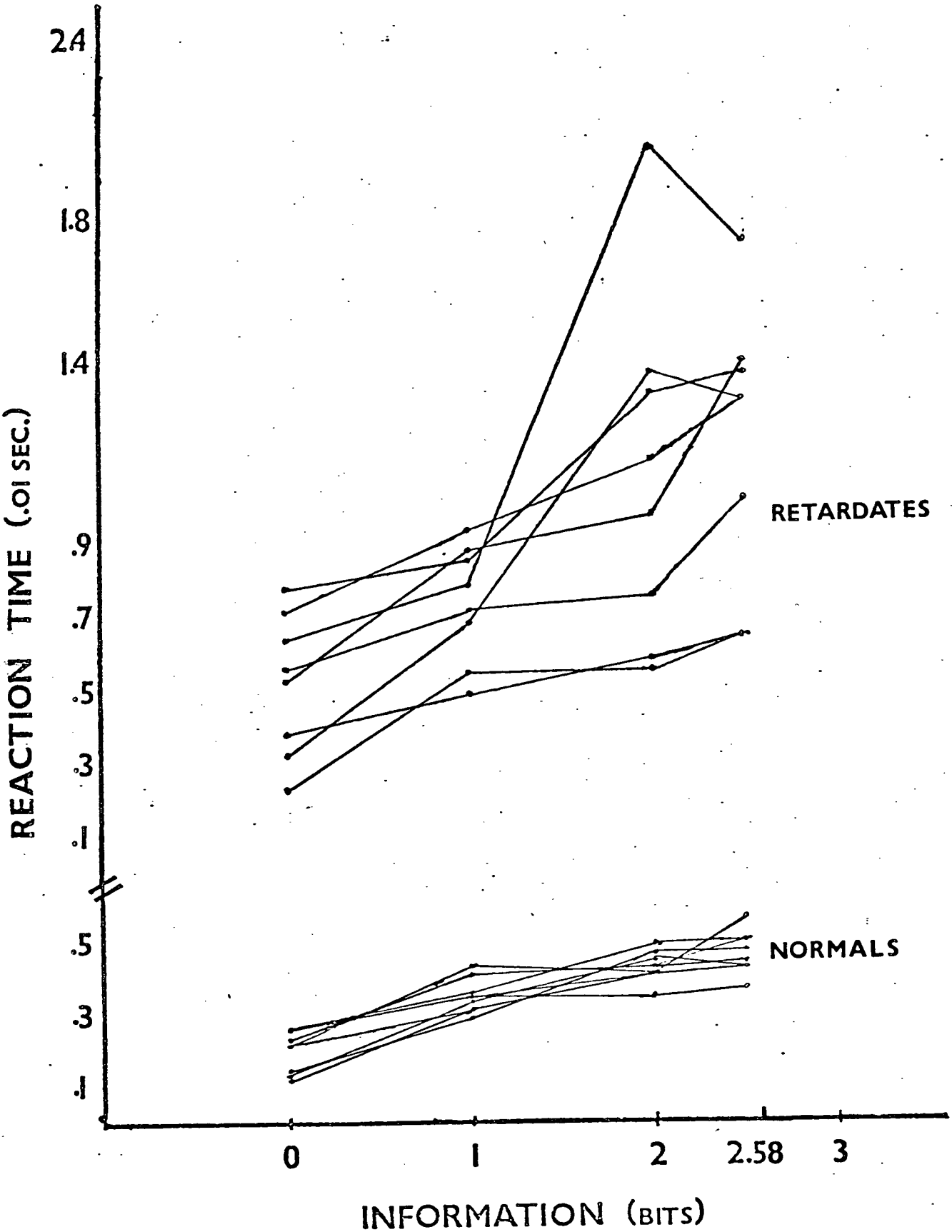

FIGURE 6: GROUP VARIABILTY - INDIVIDUAL MEAN RT_S AS A FUNCTION OF INFORMATION LOAD.

group. This over-lapping score occurred on Condition one, the simple RT condition, and can be seen in Table 5. The observed absence of over-lapping scores reveals that even though the retardates scores are quite variable, their scores, as a group, are distinctly different from those of the normal group.

Intra-Individual Variability

A study of the intra-individual variability of both the retarded and normal group has shown that the retardates were more variable within themselves than the normal SS (Table 5, Figure 7). It was also found that the intra-individual variability of the retarded Ss greatly increased on Conditions three and four while the intra-individual variability of the normal Ss remained relatively unchanged over all four conditions. This trend is similar to the trend found with the group variability. Table 5 shows the individual variance of each subject on each condition. Figure 7 compares the mean intra-individual variability of the retarded and normal group for each condition.

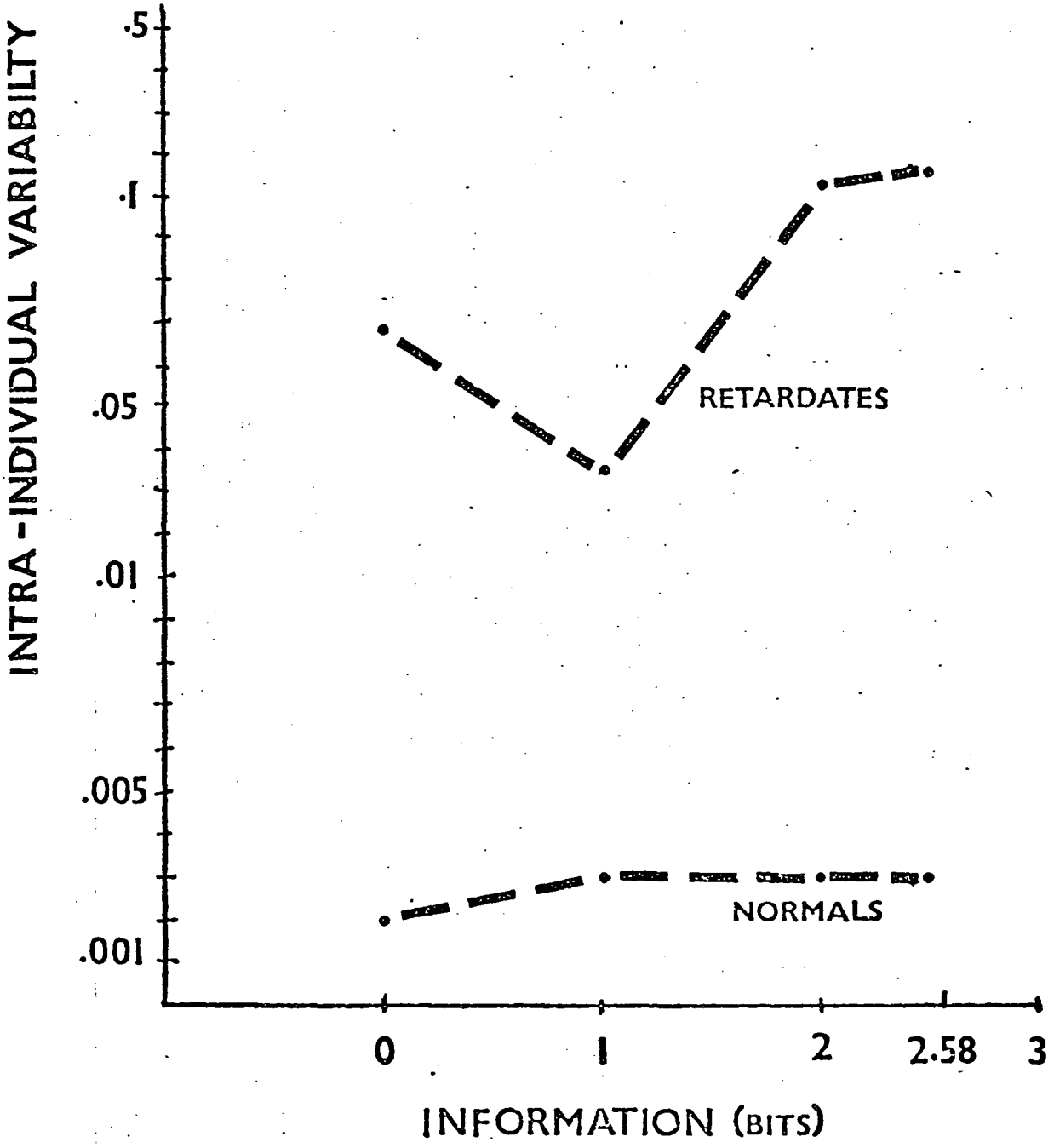

FIGURE 7: MEAN INTRA-INDIVIDUAL VARIABILITY AS A FUNCTION OF INFORMATION LOAD.

TABLE 5

INTRA-INDIVIDUAL VARIANCE OF RETARDATES AND NORMALS FOR CONDITIONS 1, 2, 3 AND 4

	Conditions			
Group 1 Retardates	1	2	3	4
Subject 1	0.016	0.108	0.132	0.551
2	0.467	0.107	0.643	0.389
3	0.003	0.015	0.145	0.090
4	0.041	0.015	0.110	0.162
5	0.009	0.012	0.009	0.021
6	0.005	0.008	0.006	0.002
7	0.001	0.005	0.007	0.011
8	0.012	0.007	0.004	0.015
Group II Normals				
Subject 1	0.002	0.008	0.004	0.000
2	0.003	0.003	0.000	0.003
3	0.001	0.004	0.011	0.001
4	0.001	0.002	0.000	0.003
5	0.001	0.000	0.007	0.004
6	0.000	0.004	0.000	0.010
7	0.004	0.002	0.002	0.002
8	0.001	0.000	0.003	0.002

DISCUSSION

Simple RT, Retardates and Normals

The first hypothesis of the present study, that retardates, as a group, have a slower than normal RT, was supported since the RT of the retarded Ss was found to be significantly slower than the RT of the normal Ss. These results are supported by the findings of a large number of investigators (Berkson, 1960a, 1960b, 1960c; Berkson and Baumeister, 1967; Baumeister and Kellas, 1968; Jones and Benton, 1968; and Jones and Hinkle, 1970. Table 6 compares the simple RT of retardates and normals in the present study with the results of two other studies.

TABLE 6

COMPARATIVE ANALYSIS OF SIMPLE RT OF RETARDATES AND NORMALS IN THE PRESENT STUDY WITH THE RESULTS OF TWO OTHER STUDIES

	Retardates		Normals	
	Mean	Variance	Mean	Variance
Present Study	0.516	0.0329	0.205	0.0013
Baumeister & Kellas, 1968	0.311	0.0077	0.158	0.0013
Jones & Hinkle, 1970	0.67	0.0676	0.34	0.0081

Jones and Hinkle suggested as an explanation of slower simple RTs in retarded Ss that,

> "perhaps even the simplest task to a retardate, presents itself as a choice situation. This is suggested by the fact that the simple RT for the retardates was equal to the CRT for normals."

The findings of the present study are contradictory to the theory offered by Jones and Hinkle. On the basis of the present results (Table 2) it is apparent that the slower simple RT of the retarded S cannot be wholly explained by the theory that retardates deal with a simple RT task as a CRT situation, since it is observed that the simple RT of the retarded group is greater than the CRT of the normal group, even on the six choice conditions in the present study. If the simple RT task does present itself as a CRT situation to the retarded S there must also be some other complication occurring in the central mechanisms of the retarded Ss, which causes the simple RT of the retardates to be greater than the CRT of the normals. It has been hypothesized, in the present study, that the slower simple RT of retardates is caused by a slower than normal information processing rate in the decision mechanism of retarded Ss.

It has become well established that, as a group, the mentally retarded have a slower simple RT than normals, however researchers have not yet discovered which mechanism, or combination of mechanisms underlie this evidenced slowness. Many theories have been offered as an explanation of this difference between normals and retardates. Berkson

(1960c) felt that some aspect of the response initiation or execution, rather than the sensory or choice components of RT, may be effected in retardates. Baumeister, Hawkins and Kellas (1965a) looked at general arousal level, and Holden (1965) suggested a pre-stimulus arousal defect. Annett (1957) felt that slower simple RTs in retardates were the result of slower information transmission by retardates. If the decision mechanism is at least one of the mechanisms involved in the decreased performance of retardates then it might be expected that increasing the information load in a CRT experiment would be accompanied by a continually increasing deficit in performance when compared to the performance of normal Ss. The following section examines this possibility.

CRT, Retardates and Normals

The second hypothesis of this study, which stated that retarded Ss process information in their decision mechanisms at a slower rate than normal, was strongly supported by the results of this study. The analysis of variance table shown in Table 3 indicates that the main effects, Groups, Conditions and Groups by Conditions interaction were all significant at the .01 level. The significant Groups effect indicates that the retardates' mean RT for all conditions was significantly different than the normals' mean RT for all conditions. The conditions effect confirms that there was a significant difference in the mean RT recorded for each condition, for both groups. A

trend analysis done on the Conditions effect revealed a significant linear trend, indicating that the change which occurred for both groups over conditions was linear. This can be seen in the graph presented in Figure 5. A linear trend was expected for the normal group since this has already been shown by Hicks (1952) and Hyman (1953). The finding of a significant linear trend for the retarded group is supported by the findings of Annett (1957), Berkson (1960c), Hawkins, Baumeister, Koenigsknecht and Kellas (1965), D. Jones and Benton (1968), and J. Jones and Hinkle (1970).

The Groups by Conditions interaction, which was also found to be significant, confirms that the two groups reacted differently to the Conditions or increasing task complexity. A trend analysis done on the Groups by Conditions interaction indicated that the change occurring was a significant (.01 level) linear change. This change can be seen in Figure 5 which shows that the retarded group reacted much more negatively to the increase in information than the normal group. These results support the major hypothesis of the present study, that retardates process information at a slower rate than normals. In terms of Welford's model, which is shown in Figure 2, the results indicate that the slower than normal simple RT common to the retarded population is partially or wholly due to some deficiency in the decision mechanism. The decision mechanism, according to Welford, is responsible for

calling-out from the effector mechanism the appropriate response to match a particular information signal received from the perceptual mechanism. It encompasses two component processes; response selection and retrieval of motor programs from motor memory, which oversees the desired motor execution. The results of the present study suggest a deficiency in one or both of these component processes of the decision mechanism. Since the present CRT experiment was designed to minimize the effects of the perceptual and effector mechanisms (Hyman ,1953) it is felt by the investigator that the present study indicates that the decision mechanism is almost entirely responsible for the delay in RT of retardates. If the perceptual or effector mechanisms are at all responsible for causing the delay in retardates in the present study, it is felt that the effect of these mechanisms would be very minimal. However, it is realized by the investigator that other studies using a complex visual display or requiring a complex motor response might find that the slow simple RT responses of retardates are due to either the perceptual or effector mechanisms. The present study confirms that the decision mechanism of retarded Ss is partially responsible for the slower than normal simple RTs found in retardates. Further studies must be done to determine the degree of responsibility of the decision mechanism. It is felt, by the investigator, that further studies may reveal that the degree of involvement of any one of the three mechanisms varies between Ss. With testing

it may be possible to determine in which of the three mechanisms a retarded person is most limited. Consequently educators would then know which of the mechanisms to concentrate their efforts towards when teaching a particular student. For example, if a retarded child was found to be limited mainly by his effector mechanism he could be assigned remedial motor tasks.

Similar to the results of the present study, Annett (1957) found an interaction between intelligence and information load. Annett tested three levels of retarded Ss (high, medium and low grade), and found that for all three groups of Ss the regression of time on information was linear, and the slopes of each line were significantly different from each other. These results are shown graphically in Figure 8.

Annett concluded from his study that low and mid grade retardates have a lower information capacity than normals (although he did not test normals on the experimental task he used in his study). Because of weaknesses in the design of Annett's experiment, the results must be viewed with some skeptism. It is felt by the investigator that Annett's peg-board assembly task failed to minimize the roles of the perceptual and effector mechanisms. Also, by recording Reach time Annett was actually measuring movement time (MT) rather than RT and thereby involving the effector mechanism. Annett's study has implicated the decision mechanism as the cause of the delay, however his experimental design

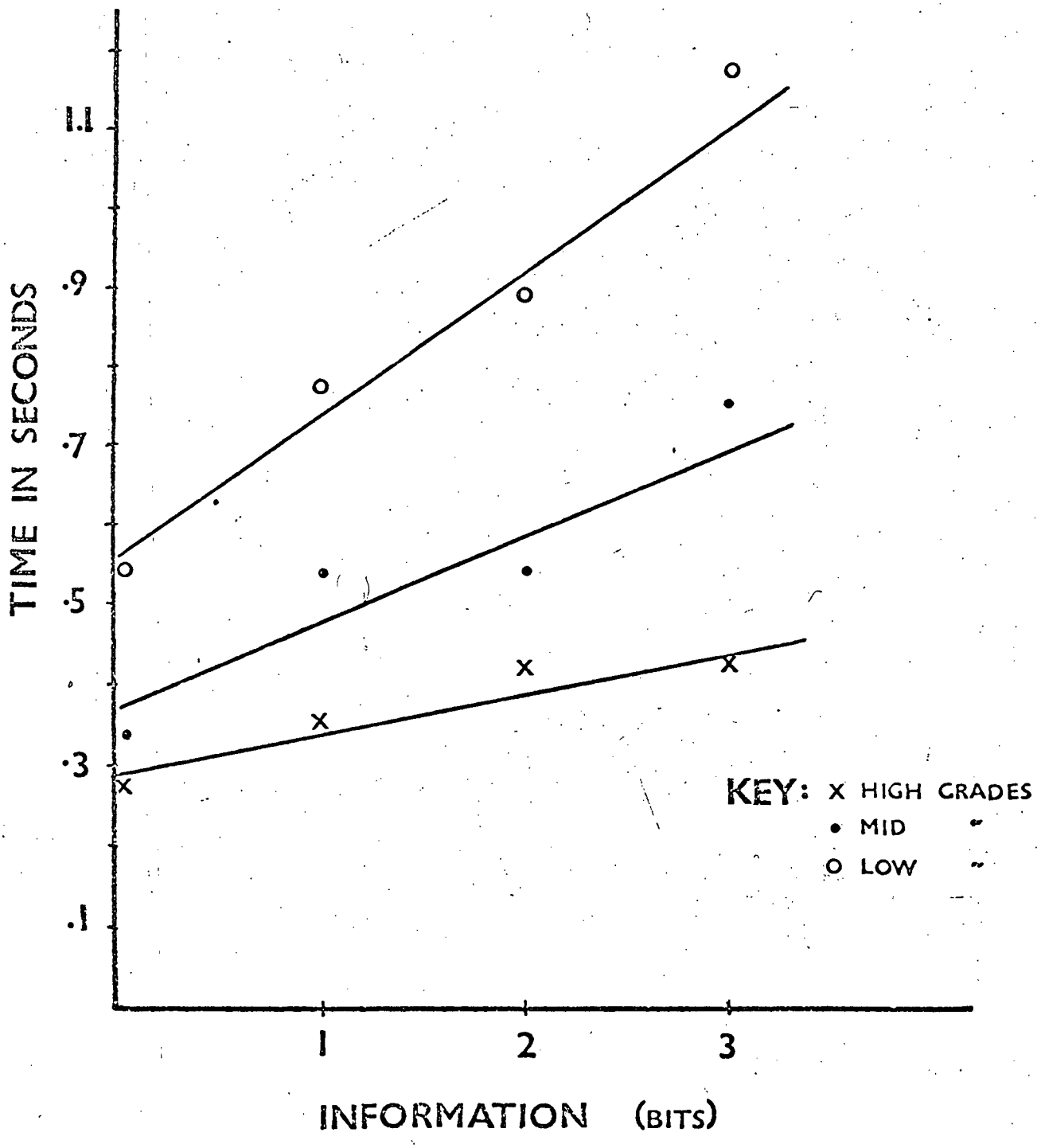

FIGURE 8: MEAN TIMES AND REGRESSION OF TIME ON INFORMATION (ANNETT 1957).

failed to isolate the decision mechanism. The present study was designed to eliminate as much as possible the roles of the perceptual and effector mechanisms and see if the relationship found in Annett's study still remained. The results of the present study revealed a significant interaction between Intelligence Groups and Conditions (information load) confirming that the decision mechanism is partially responsible for the delay in RT in retardates.

A recent study by Berkson (1960c) offers a theory which is contradictory to that advanced by the investigator. Berkson failed to find a significant interaction between Intelligence and RT Task (information load) but did find a significant interaction between Intelligence and Response Task (task requiring a complex motor response). He concluded that I.Q. is related to functions involved in the initiation or performance of a response.

It is felt by the investigator that Berkson failed to find a significant I.Q. by RT task interaction because of the design of his experimental task. Berkson required his Ss to suppress a button with their right index finger. When a stimulus light came on they were to release the suppressed button and turn the light off by pressing the appropriate response button. RT was measured as the elapse in time between the presentation of the stimulus light and the release of the suppressed button. It is felt by the investigator that it is possible the Ss released the suppressed button and <u>then</u> made their choice of which button to press.

With the excitable nature observed in the retarded children in the present study and their strong desire to do the task as quickly as possible, as they were instructed, it is felt possible that the experimenter did not obtain true CRT scores for the retarded Ss.

A study by Hawkins, Baumeister, Koenigsknecht and Kellas (1965) also failed to find a significant interaction between Intelligence and Task Complexity. This study purported to improve on what the experimenters felt were the weaknesses of Berkson's study, by using a response which did not vary with task complexity and which was relatively free of complex motor elements. It is felt by the investigator that, while improving on Berkson's study the design of the study by Hawkins et al. was still weak since task complexity was only increased from one to two alternatives. Hawkins et al. also recognized this as a weakness of their study since they mentioned in the discussion that a task involving a larger number of alternatives may have produced the predicted interaction.

Group Variability

The results of this study (Table 2) revealed a high degree of variance in the retarded population as compared to the normal population. This large degree of group variability noted in the present study has also been found in other studies dealing with the retarded population. Berkson and Baumeister (1967) noted that in addition to

being slower than normals in a RT task, retardates are more variable both between and within Ss. Baumeister and Kellas (1968) also noted that the RT responses of retarded Ss are much more variable than those of normal Ss.

Many suggestions such as, individual differences in arousal levels, individual differences in receptability to encouragement, and individual differences in noise levels have been offered to explain the large degree of group variability in RT responses of retardates. However, the results of the present study seem to indicate a relationship between variability and informational load. Table 2 and Figure 6 clearly show a large increase in the group variability of retardates on Conditions three and four, the more complex conditions. The group variability of the normal Ss, by comparison, is consistent over all four conditions. These results support the theory that the RTs of retarded Ss are influenced more by increases in information load than normal subjects and consequently lend indirect support to the second hypothesis of this study.

Intra-individual Variability

The results (Table 5) of the present study showed that the retarded Ss were more variable within themselves than the normal Ss. This finding is supported by both Berkson and Baumeister (1967) and Baumeister and Kellas (1968). Baumeister and Berkson felt that the high intra-individual variability of the retarded Ss was an indication

they were not working at their maximum efficiency level. Further they suggested that the true RT of retarded Ss may be near that of normals, but that they are simply less efficient at maintaining this optimum response level. Baumeister and Kellas (1968) felt that the high degree of intra-individual variability in retarded Ss was due to variable attentional or arousal fluctuations of retarded Ss. Figure 7 and Table 5 reveal that the intra-individual variability of the retarded Ss of the present study greatly increased on the more complex conditions (three and four). The intra-individual variability of the normal Ss, by comparison, was consistent over all four conditions. These results appear to indicate a relationship between intelligence and intra-individual variability.

Thus it would appear that the present study supports the finding that retarded Ss tend to be more variable than normal Ss both as a group and within themselves, and adds the fact that variability of performance, for the retarded Ss increases as they are faced with increasing information demands. The exact cause of this increase in variability is not known.

CHAPTER V

SUMMARY AND CONCLUSIONS

The purpose of this study was to determine whether the delay in RT of retarded Ss was the result of retardates processing information in their D.M. at a slower rate than normals. A CRT experiment, with four different levels of information load, was used to examine the information processing rate of retarded and normal Ss. Eight, right-handed boys between 10 and 12 years of age, with average intelligence (I.Q. 95-105), and eight, right-handed boys between 10 and 12 years of age, with below average intelligence (I.Q. 40-54), were tested on all four conditions of the CRT task. An analysis of variance test was performed on the data.

It was found on the basis of the test analysis that both the simple and choice RT of retarded Ss was significantly slower than the simple and choice RT of the normal Ss. A significant Conditions effect revealed that there was significant differences in the mean Rts recorded over all four conditions. A trend analysis done on the Conditions effect showed that the change which occurred, for both groups, over Conditions was linear. A significant Intelligence Groups by Conditions interaction further revealed that the two intelligence groups reacted differently to the four conditions, or

increasing task complexity. A trend analysis done on the Groups by Conditions interaction indicated that the change occurring was a significant (.01 level) linear change. These results indicated that, in terms of the task used, the delay in RT of retarded Ss is the result of deficiencies in the D.M. of retarded Ss.

It was also found that both the group and intra-individual variability of the RT responses of the retarded Ss was much greater than the group and intra-individual variability of the RT responses of normal Ss. On Conditions three and four, the more complex conditions, there was a large increase in both the group and intra-individual variability of the RT responses of the retarded Ss. By comparison the group and intra-individual variability of the RT responses of the normal SS was consistent over all four conditions. These results provided additional support for the theory that retarded Ss are more severely affected by increases in information load than normal Ss.

The conclusions of this experiment were:

1. That the simple RT of retarded Ss is slower than the simple RT of normal Ss.
2. That retardates process information in their D.M. at a slower rate than normals, and that this contributes to the delay in RT of retarded Ss.
3. That the RT responses of retarded Ss are more variable, both as a group and within individuals, than the RT responses of normal Ss.

4. That both the group and intra-individual variability of the RT responses of retarded Ss increases with increases in information, while by comparison, the group and intra-individual variability of RT responses of normal Ss is unaffected by increases in information.

Recommendations

1. That further studies testing RT of retarded subjects use a gross motor response, similar to that used in Austin's study (1969), since retarded subjects appear to have difficulty with fine motor movements.
2. Further individual study of the perceptual decision or effector mechanisms of retarded Ss, in comparison with normal Ss, is recommended in order to determine the unique characteristics of the retarded population in relation to these mechanisms.
3. Further study of the perceptual decision and effector mechanisms of retarded Ss is recommended in order to determine to what degree each mechanism contributes to the delay in RT of retarded Ss.

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APPENDIX A

RESULTS FROM PILOT STUDY

RESULTS OF TWO SUBJECTS FOR FOUR LEVELS OF INFORMATION LOAD

SUBJECT	INFORMATION			
	0 Bits	1 Bits	2 Bits	2.58 Bits
SUBJECT A (Male 17 yrs)	.203	.359	.973	.684
	.432	.375	.533	.734
	.615	.397	.574	.876
	.132	.424	.601	.711
	.142	.350	.407	.691
	.159	.299	.431	.753
	.213	.400	.722	.893
	.181	.347	.581	.751
	.191	.560	.373	.901
	.198	.301	.614	.962
SUBJECT B (Female 11 yrs)	.212	.391	.995	.606
	.233	.444	.726	.406
	.241	.350	.714	.573
	.217	.372	.584	.358
	.199	.451	.534	.648
	.209	.477	.736	.390
	.202	.516	.538	.376
	.194	.497	.521	.366
	.221	.481	.600	.550
	.213	.518	.443	.308

MEAN RESULTS OF TWO SUBJECTS
FOR FOUR LEVELS OF INFORMATION LOAD

	INFORMATION			
	0 BITS	1 BIT	2 BITS	2.58 BITS
SUBJECTS				
SUBJECT A	.246	.381	.580	795.6
SUBJECT B	.214	.450	.641	558

APPENDIX B

INSTRUCTIONS USED IN PILOT STUDY AND STUDY

INSTRUCTIONS

- (subject's name), this is a game to see how fast you can press the buttons with your fingers. In order to play properly you must put one of your fingers on each of the black buttons, (demonstrate). Make sure you curl your other fingers out of the way, (demonstrate).

- Try pressing each button one at a time, with the finger that is covering it. (Practise 3 or 4 times, or until subject does five consecutive trials without a mistake).

- Now, when I say "ready" make sure that your fingers are on the buttons, and watch the yellow light, (E. points to warning light).

- Just after I say "ready" the yellow light will come on, (demonstrate).

- As soon as that light goes off one of the red lights will come on, (demonstrate).

- You must try to make the red light go off as fast as you can by pressing the button that is joined to it by the tape (3 or 4 trials).

- For the first game I am going to cover all but two, (1, 4 or 6) of the red lights. This means that as soon as the yellow light goes out either this light (point) or this light (point) will come on. You must decide which light has come on and which button to press to make it go off. Remember you must turn it off as fast as you can. (5 practice trials on each condition to be tested).

APPENDIX C

INDIVIDUAL SCORE SHEETS

NAME:_____

AGE: _____

CONDITION A			CONDITION B		
Foreperiod		Results	Stimulus		Results
2	1.		1	1.	
4	2.		2	2.	
3	3.		2	3.	
4	4.		2	4.	
3	5.		2	5.	
4	6.		1	6.	
4	7.		1	7.	
4	8.		1	8.	
1	9.		1	9.	
3	10.		2	10.	
1			2	11.	
3			1	12.	
2			2	13.	
4			2	14.	
1			1	15.	
4			1	16.	
1			1	17.	
1			2	18.	
4			1	19.	
2			2	20.	

NAME: _____

AGE: _____

	CONDITION C				CONDITION D			
Fore-period	Stimuli	Results	Stimuli	Results	Stimuli	Results	Stimuli	Results
4	2	1.	4	31.	1	1.	1	31.
4	3	2.	1	32.	2	2.	4	32.
4	2	3.	3	33.	6	3.	5	33.
3	4	4.	2	34.	3	4.	1	34.
4	3	5.	1	35.	3	5.	5	35.
2	4	6.	2	36.	1	6.	3	36.
3	1	7.	3	37.	3	7.	4	37.
2	4	8.	4	38.	2	8.	5	38.
2	4	9.	3	39.	3	9.	2	39.
4	3	10.	1	40.	3	10.	6	40.
2	4	11.			4	11.	1	41.
2	3	12.			1	12.	6	42.
2	4	13.			4	13.	1	43.
3	4	14.			5	14.	5	44.
2	1	15.			3	15.	6	45.
2	1	16.			3	16.	4	46.
2	3	17.			6	17.	3	47.
2	1	18.			2	18.	2	48.
4	2	19.			6	19.	4	49.
3	1	20.			1	20.	5	50.
4	2	21.			5	21.	4	51.
2	3	22.			2	22.	6	52.
2	2	23.			5	23.	2	53.
2	2	24.			2	24.	6	54.
2	2	25.			1	25.	6	55.
3	2	26.			1	26.	2	56.
4	1	27.			5	27.	3	57.
3	4	28.			4	28.	4	58.
2	1	29.			2	29.	5	59.
3	3	30.			4	30.	6	60.