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PUPILLARY ACTIVITY DURING VISUAL AND AUDITORY ANAGRAM SOLUTION

by

© JUDY ANNE CALLIE CHAPMAN

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ABSTRACT

This study was an attempt to investigate the possiblity of differences in the occurrence of the orientation reaction (O.R.) of educable mentally retarded (E.M.R.) children as compared to normal children during a task-oriented activity. Accordingly, the pupillary component of the O.R. was measured during the solution time of four auditorally and four visually presented three-letter anagrams for 27 E.M.R. children and 19 normal children, who were from nine to twelve years of age. The solution period was vincentized into thirds and analyzed accordingly. The variable of solving as compared to the not solving both types of sensory anagrams was investigated utilizing, however, only part of the total sample.

It was found from the results that normals produce greater amounts of pupillary dilation than E.M.R.'s during anagram solution in both sensory modalities. In addition, for visually presented anagrams, the difference between normals and E.M.R.'s increased as a function of periods of solution with the first period showing the least difference and the third period of solution showing the greatest difference. The analyses involving the variable of solved versus not solved anagrams showed no significant effect for this variable.

It was concluded that normals show greater amounts of dilation during anagram solving for both auditory and visual sensory modalities; and, in accordance with previous research, that for visual anagrams this difference between E.M.R.'s and normals increases as a positive function of periods of solution time. It was also concluded, that the actual solving or not solving of an anagram does not appear to be a significant

variable affecting the occurrence of pupillary dilation.

These results and conclusions were discussed in terms of Berlyne's theory of attention suggesting that the greater amounts of dilation shown by the normals is indicative of their ability for more effective and greater amounts of attention towards task-relevant stimuli resulting in better anagram solving behavior.

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TABLE OF CONTENTS

CHAPTER PAGE

LIST OF TABLES

LIST OF FIGURES

FIGURE PAGE

CHAPTER I

Introduction

In order to create learning environments which are as effective as possible, it is necessary to comprehend and utilize the variables that are significantly involved in the learning process. Our present knowledge of these variables for the child which we identify as educable mentally retarded is less than complete making research in this area essential.

Luria (1958, 1963) in discussing Russian research with child oligophrenics expresses a point of view which he sees as the basis for Russian investigation into mental retardation. He differentiates between what he terms the "symptomatic approach" of the West and the Soviet approach termed "causal dynamic". He suggests that the Western approach emphasizes a conception of mentally retarded children as being backward because of an inborn mental deficiency or an inherent dullness which is irreversible. This attitude places the mentally retarded at the lower end of the normal distribution of intelligence, in a position which is unescapable. Luria distinguishes between the two approaches in the following manner:

> Must we confine our research to external clinical description of such children, or should we in accordance with our general principle, go further and set ourselves the task of qualifying their disturbances? Should we attempt to disclose the changes which underlie the anomalous development and to express the disturbance in more profound pathophysiological units? (1958, p. 368)

This point of view can be extended to refer not only to oligophrenics (that is, brain damaged individuals) but also to the educable mentally retarded child. It is necessary that the recognition of etiology be a factor in the examination of the retarded. However, regardless of etiology, the basis for research can remain the same as stated by Luria in the causal dynamic approach. The rationale in pursuing this investigation on pupil dilation with the educable mentally retarded is in accordance with the point of view of discovering and learning more about why the retarded child is deficient in his apparent functioning during cognitive tasks through the use of physiological measures.

It is a generally accepted assumption that a necessary prerequisite to learning consists of the selective attention of the individual to relevant stimuli. It is also commonly accepted by many that one component of selective aspects of attention involves the orientation reaction. Thus, if effective learning environments are to be created, then elements such as the orientation reaction (O.R.) must be understood and if necessary, brought under instructional control.

In recent years, there has been an increasing amount of research devoted to defining the components of the O.R. and evaluating its functioning during task-related activities. In addition, there has been an increase in the use of the O.R. to facilitate both the diagnosis as well as the understanding of learning deficits in the mentally retarded child. The O.R. is by no means a well-understood or well-defined construct. It is thought to be a reaction to the perception of a stimulus which is novel or meaningful to the individual, making the individual more capable of processing information concerning that stimulus.

In reviewing the literature (e.g. Berlyne, 1960; Gray, 1966; Lynn, 1966) it has been suggested that there are five basic components of the O.R. First, there is an increase in the responsiveness of the sense organs which is exemplified by changes in pupil dilation, a lowering of the threshold for intensity of light in the retina through photochemical changes and a lowering of the auditory threshold. The second component involves the alteration of the skeletal muscles for the purpose of guiding the sense organs, e.g. an animal turning its head toward the source of the stimulus and pricking up its ears. A third component consists of electroencephalographic (E.E.G.) changes, one of which is alpha-blocking giving rise to a more irregular and faster pattern of E.E.G. activity; a fourth component is a general skeletal musculature change such as a rise in the general muscle tone and a discontinuation of the subject's ongoing activity. Vegetative changes comprise the final component. These changes consist of the galvanic skin reaction; vasodilation in the head concurrent with vasoconstriction in the limbs; and cardiac and respiratory changes, the directions of which are as yet somewhat inconsistent, depending upon task demands.

The results from recent research (e.g. Boersma, Wilton, Barham and Muri, 1970; Luria, 1963) have indicated that the mentally retarded child exhibits an atypical O.R. Since the ability of the organism to deal with a novel stimulus by taking in and processing information about that stimulus is enhanced by the O.R., it follows that an inaccurate or inefficient O.R. will adversely effect the mental processes involving stimulus input. Without adequate processes for stimulus input, optimal learning cannot occur.

It seems justified to state that the retarded child has more unsuccessful experiences in solving cognitive problems than the child of normal ability. A question arising from this point concerns the effect of solution upon the successive O.R. Boersma et al. (1970) have speculated that the solving or not solving of a problem may effect the functioning of the O.R. This speculation can be empirically tested through the use of physiological measures of the O.R. during solution periods.

The acceptance of these ideas regarding selective attention capacities of the mentally retarded is dependent on a great deal of further investigation. The relatively large number of educable mentally retarded children in our school systems and their manifest problems in the classroom makes the relevance of this type of research apparent. The overt behavior of the educable mentally retarded within the learning situation is often characterized by a lack of attention to relevant stimuli and a heightened susceptibliity to fatigue. This type of child tends to need more time to acquire and integrate information and often has to cope with emotional adjustments due to a general pattern of academic failure and frustration. Learning in a formal setting is an integral and vital aspect of effective living in our society. Thus, if the deficient learning processes of the educable mentally retarded are in part due to malfunctioning of the O.R., this issue must be remedied in order for them to reach their optimum level of education. The present investigation was formulated to provide information about one component of the O.R., pupillary dilation, with educable mentally retarded children in order to assess the relative import of this measure during a cognitive activity.

Literature Review

Two basic considerations will now be presented. The purpose of the first section is to provide a general framework for the reader in examining this investigation. It is intended to provide a broad perspective as to the scope of the theoretical implications of the research problem pursued. This first section will include a discussion of apparent attentional problems of the educable mentally retarded and an outline of difficulties in attaining sound research; subsequently, a theory of attention will be presented.

The second position is considerably more specific to the research problem presented. It is comprised of an explanation and discussion of the orientation reaction and the presentation of research involving pupil dilation during cognitive processing tasks.

Attention and the retardate

Attention is considered to be a prerequisite for learning. It is not uncommon to hear a teacher lament over not being able to gain the attention of students in order to teach them. The age old problem of getting students to attend to relevant stimuli is one of the major emphases in teacher training through the study of motivation and curriculum development. The child who does poorly is frequently accused of not paying attention or not being able to attend to his work for sufficiently long periods of time. The analysis and understanding of the concept of attention in learning and education is indeed a vital but complex matter.

Whereas the lack of attention for learning in a normal classroom situation is presented by educators as a recurring problem, it becomes even more obvious and frequent in a classroom of the educable mentally retarded. Crosby and Blatt (1968) state that "professional opinion" has long viewed a lack of attention as a general characteristic of the mentally retarded. This opinion is commonly expressed in phrases such as "distractibility", "inability to concentrate" or "short attention span". They continue by citing four theorists who maintain this position:

1. The low probability of mentally retarded subjects attending to the relevent stimulus dimensions of a stimulus situation, not the inability to discriminate which cue is correct, is seen as the retarded child's impairment in visual discrimination learning by Zeaman and House (1963).

2. "Defective acquisition" is seen as the problem in the learning difficulties of the retarded by O'Conner and Hermelin (1963) as compared to poor perception, retention, or transfer. They go on to state that this defective acquisition is caused by lack of attention to relevant stimuli.

3. An attention deficit is postulated by Denny (1964) to be the causal factor in the problems of learning for the retardate in both incidental and discrimination learning.

4. Luria (1963) states that a defect in the orientation reaction of the mentally retarded is responsible for ineffecent attention to new and relevant stimuli, thereby producing a learning deficit.

As illustrated, there is general agreement that an attentional deficit appears to be a formidable problem for the retardate. However, there are numerous theories purporting to explain this attention deficit ranging from personality theories (e.g. Hutt and Gibbey, 1965) through physiological theories (e.g. Luria, 1963). The very breadth of these explanations exemplifies the quandry in which these theories have been proposed. This quandry is based in part upon the present difficulties in defining the phenomenon of attention.

Considerations in definition and investigation of attention

Mostofsky (1968) has provided an analysis of the various theoretical forms with which the concept of attention has been associated. The general tone of the paper suggests a pervasive and intuitive feeling that attention is easily comprehended without having satisfactorily researched prevalent theories. Although Mostofsky presents a critical analysis of the present theories and research of attention, he concludes that the concept of attention is indeed necessary and beneficial for psychology. In examining attention, the three major problem areas which he has identified are worthy of consideration.

First, he considers circularity to be a problem in the definition of attention by some researchers. For example, Zeaman and House (1963) have suggested that the deficit in the retarded during discrimination learning is due to problems of attention to relevant stimulus dimensions, but not to inherent problems in the discrimination process. Their conclusion is based on results derived from the use of backward learning curves which illustrated that once a subject of lower mental age (M.A.)

begins to increase in accuracy to criterion, his rate of learning is very similar to subjects of a higher M.A. However, the lower M.A. subjects take a longer number of trials during which the probability of producing the correct response is at a chance level prior to the rise to criterion. At the same time, it is shown that the children lacked attention because of failure of these lower M.A. subjects to make the correct response during this initial time period prior to learning the task. As illustrated, the use of attention is being simultaneously involved to explain deficits in the perception of stimulus and resulting behaviors, while it is also being inferred from the presence or absence of these same behaviors during the same task. However, through the use of a concommittant physiological measurement of attention, e.g. pupillary dilation, one can overcome this criticism.

A second major criticism is cited by Mostofsky in defining attention through the use of physiological data when no such relationship between the conceptual and biological aspects of attention necessarily exists. He stresses the importance of very carefully designed research and warns against the faults of simply substituting mentalistic terms for physiological terms. He suggests that the research of Hernandez-Peon and his associates is a case in point for this type of criticism. This work led to the study of attention behaviorally through the analysis of the form of altered neural findings following presentation of attention-getting stimuli. Worden (1966) explains and criticizes the observation of Hernandez-Peon in terms of inadequate sampling procedures and failure to control relevant variables. This critique maintains that the evidence regarding attentive behaviors in these studies is thereby unfounded. The rejection of all attention research based on physiological data would be illogical. However, it is valuable to consider such criticisms when developing research projects and these criticisms indicate the need for sound methodological research designs and logical reasoning in this area.

The third consideration lies in the continued use of the concept of attention as an explanatory process in dealing with human perception. The objection to its use is based on the possibility of redundancy between it and other concepts such as stimulus control.

Upon close examination, however, the possibility of redundancy appears minimal. Thus, in examining studies of vigilance, for example, stimulus control is a transient variable whereas attention is not. The subject's observant behavior during the absence of a stimulus cannot be explained in terms of stimulus control and an alternative concept (e.g. attention) is required. The construct attention may also prove to be useful in understanding an organism's behavior when it has been preceded by a history of reinforcement. Althought the concept of stimulus control appears sufficient in understanding classical conditioning, Mostofsky states that it is probably not sufficient for understanding operant conditioning and goes further to suggest that the concept of attention may be helpful in clarifying the differences between these two types of conditioning. Although this possibility is speculative, he feels it would be premature at this stage to eliminate attention without further examination.

The observations expressed by Mostofsky are critical in the formulation and interpretation of the research problem presented, which has a dependent variable based on a component of the O.R. (that is, the change in pupil dilation). These criticisms indicate the need for stringent limits in the utilization and interpretation of this data. More specifically, any reference to attention in interpreting this data must be done with caution keeping the following points in mind. The relationship of the O.R. to attention is as yet tenuous. Therefore, it follows that the utilization of the constructs of attention theory to explain changes in pupillary activity should be done in a speculative fashion. However, the following theoretical framework of attention seems to provide an extensive and reasonable position, and will serve as the basis of the present investigation.

Berlyne's theory of attention

In the late nineteenth and early twentieth century, attention was one of the major concepts being developed and investigated in psychology. An illustration of this effect is provided by Titchener's (1908) belief that any theory of psychology would be judged according to its recognition of attention. This emphasis on attention did not last, however, and it has only recently been revitalized. The renewed emphasis is in part based upon recent knowledge in the field of neurology (Hernandez-Peon, 1966) and physiology (for e.g. Luria, 1963; Lynn, 1966; Sokolov, 1958). In order to comprehend the relevance of a study involving pupil dilation, it is necessary to understand what relationship between the O.R. and attention has been proposed. Berlyne's theory of attention may provide a carefully structured delineation between these two constructs, without sacrificing the necessary flexibility for interpreting data concerning a construct such as the O.R. Berlyne (1960, 1970) distinguishes between two principal areas of attention, intensive and selective, although he states that it is commonly held that both functions are probably controlled by closely related processes. Within both of these areas, he has developed three specialized aspects to attention.

The three intensive aspects will be presented first.

A. Attentiveness is the amount or degree that an individual is responding to his external environment. In other words attentiveness depends upon how much the individual is reacting to external stimuli. If an organism is making motor responses and simultaneously oblivious to his external environment, his attentiveness would be at its lowest ebb. The term vigilance is often used in a synonomous manner with this meaning of attentiveness.

B. Degree of concentration is evident when there are competing stimuli acting on the organism. The amount of information being transmitted by a particular stimulus can be considered to be a function of the degree of concentration on that stimulus. This concept is equivalent to the notion of someone not paying attention to what he is doing.

C. Arousal is the third aspect of the intensive phase of attention. It is considered a part of intensive attention because of the occurrence of increased arousal especially that of E.E.G. alpha blocking upon the presentation of stimuli which would appear to demand a subject's attentional processes. This increase in arousal, which includes some components of the orientation reaction, can enable the subject to receive and apply information about the stimuli. However, Berlyne (1970) points out that an extreme increase in arousal can inhibit an individual's attention to his environment. For this reason, the concept of arousal is not analogous to that of attention.

The three selective aspects proposed are as follows.

A. The first is selective attention, and it is to this aspect that Berlyne confines the term attention. He states, "the motor response is determined by stimuli impinging on certain receptors, while stimuli impinging on other receptors do not affect it" (1970, p. 31). This process is then divided into three further categories:

(1) Attention in performance is Berlyne's term for the process which is ongoing when more than one stimulus is being perceived, both of which require incompatable motor responses, and one of those motor responses is performed.

(2) Attention in learning occurs when more than one stimulus is being perceived and the responses of the organism are under the control of reinforcing conditions. The process in which one of the stimuli is associated with the reinforcement is an example of attention in learning.

(3) Attention in remembering is the differential process of remembering one of a number of stimuli impinging on different receptors.

Berlyne's trichotomy within his definition of attention is not necessarily fixed and permanently differentiated. It is suggested, however, that these three types of attention can not be assumed to be synonymous until a great deal more evidence is available.

B. The second aspect of the selective process is that of abstraction. This concept is most clearly illustrated by discrimination learning when an organism is receiving a number of stimulus cues from one stimulus complex impinging on one sensory receptor and not between two or more sensory receptors. For example, when an organism has learned to attend to the shape of an object and not its color, it is called abstraction because both color and shape impinge upon the visual sensory receptor. This process may prove to be neurologically different from that of selective attention, in that selective attention is thought to be composed of competing stimulus cues which originate in two or more locations and therefore excite a number of receptors. Lack of research in this area, however, renders these ideas speculative.

C. The third selective aspect of attention is that of exploratory behavior, which, along with arousal, embodies the components of the orientation reaction. In Berlyne's words, "Exploratory responses can help one stimulus to win the contest for attention by raising its intensity and weakening or eliminating its most formidable rivals". (1960, p. 78).

Locomotive exploration includes gross body movement whereas investigatory responses are distinguished through responses which affect a change in stimulus objects through direct manipulation on the part of the individual. The third group of exploratory responses consist of responses which are also components of the O.R. and Berlyne calls them the orienting responses. These responses affect the sensitivity or positioning of the sense organs, and it is this group of responses with which this investigation is concerned.

Since the O.R. is associated with both arousal and exploratory behavior, it cannot be classified solely under intensive or selective aspects of attention as outlined by Berlyne. The autonomic components of the O.R. (e.g. changes in E.E.G. and G.S.R.) seem to be associated with an integral part of the arousal construct. On the other hand, the orienting responses defined by Berlyne as responses which sensitize or position the sense organs (e.g. pupil dilation or skeletal movement) fall under the classification of exploratory responses. It is clear that the classification of the O.R. within Berlyne's theory of attention is at a formative stage and requires more investigation. His theory, however, clearly differentiates between the O.R. and selective attention, the O.R. being considered as an attentional process (arousal or exploratory) which subserves selective attention by acting as an initial screening or sensitization process for external stimuli. It is following this screening or sensitization process that selective attention occurs.

The orientation reaction

From literature and theories cited in the previous section of this chapter, it is apparent that further investigation is needed into the attentional processes of the mentally retarded child. It was also shown that the orientation reaction is subsumed under arousal and exploratory aspects of attention although this relationship requires more research to be clearly demonstrated. Consequently, a more detailed look at the O.R. and more specifically at one component, pupil dilation, will be presented.

The purpose of the O.R. is to increase the ability of the organism to take in and process information or to deal with novel stimuli (Lynn, 1966). Sokolov (1958) describes the O.R. as the "non-specific tuning of the analyzers when there is a newly appeared stimulus" (p. 141). The functions and components of the O.R. have been described by several authors (Berlyne, 1960; Biriukov, 1958; Lynn, 1966;

Razran, 1964; and Sokolov, 1958, 1963). It is generally agreed that the O.R. consists of five major components.

1. There is an increase in the sensitivity of the sense organs which includes dilation of the pupil and lowering of the auditory and visual thresholds.

2. An alteration in skeletal muscles occurs (e.g. turning of the head) in order to guide the sense organs.

3. There is a change in the general skeletal musculature readying the organism for activity in the skeletal muscles such as moving toward the stimulus. This change is illustrated by a general rise in muscle tonus and a momentary discontinuation of the organism's ongoing activities.

4. A change in E.E.G. activity toward increased arousal takes place, exemplified by alpha-blocking giving rise to a more irregular and faster pattern of activity.

5. Vegetative changes constitute another component of the O.R. including the galvanic skin response and vasodilation in the head concurrent with vasoconstriction in the limbs. There are also changes in respiration and heart rates, however, the direction of these changes is as yet undetermined. There is some evidence (Lynn, 1966) that in humans there is a pause in respiration followed by an activity pattern of decreased frequency and increased amplitude, and a slowing down of the heart rate.

The proposed composition of the O.R. is based on both theoretical principles and research, although it is not, as yet, a clearly-understood phenomena. Liberman (1958) cites evidence indicating that pupil dilation is an integral part of the O.R. Reporting on numberous studies done in his clinic, he demonstrates its occurrence to a variety of neutral stimuli presented through any analyser. As well, its habituation and recovery characteristics are analogous to those of other components of the O.R. He goes further to suggest that the pupillary component may prove to be more useful in research than that of the readily acceptable vascular component. In discussing Russian research, Razran (1964) states that pupillary dilation has been shown to almost invariably be the first reaction to nonvisual stimuli. With respect to visual stimuli, pupil dilation occurs as the organism's first reaction about 20 per cent of the time. Pupillary constriction as an initial reaction during the remaining 80 per cent of presentations of the visual stimulus is interpreted as an adaptive reflex occuring because of increased illumination.

According to Sokolov (1958), all of the cited components of the O.R. are characterized by the same general traits. They are non-specific, that is, they do not have a specific reflexogeneous zone, nor are they tied to specific properties of any stimuli. The occurrence of the components of the O.R. upon hearing a change in the intensity of a tone, whether it be softer or louder is an example of what Sokolov means when he talks about the O.R. not being tied to specific properties of a stimulus. In other words the O.R. does not increase with louder tones and decrease with softer ones. It is present upon the occurrence of change in a stimulus regardless of the direction of that change. This notion appears consistent with Berlyne's position with respect to collative variables which are also non-specific. The components of the O.R. are also capable of being extinguished with repeated presentation of a stimulus; however, they recover to stimulus change. Lastly, all seem to be present upon direct stimulation of the reticular system.

Novel stimuli are capable of producing more than just the O.R. Although the O.R. is typically the initial reaction to a stimulus, it can then be replaced by an adaptive reaction (in the presence of weak stimuli) or a defensive reaction (in the presence of severely intense stimuli). The characteristic which most noteably distinguishes the O.R. is its comparably quick rate of habituation. However, there are other important distinctions between the O.R. and adaptive reactions.

Where the adaptive reaction is a homeostatic reaction trying to preserve equilibrium, the O.R. exists to increase sensitivity to stimulation. An example is the occurrence of pupillary dilation. Pupil dilation as an adaptive reflex is local in nature meaning that it should only occur during changes in visual stimulation. However, the pupil dilation component of the O.R. is non-specific and therefore occurs during stimulation of any analyser (Liberman, 1958).

Another reaction which can be confused with the O.R. is that of arousal. The two are in some way related but they are not considered to be the same. Sokolov (1958) has identified different types of the O.R. which are helpful in understanding the relationship between arousal and the O.R. Although there is some disagreement (Berlyne, 1960) to this interpretation, Lynn (1966) has included these types in a dichotomy which includes the generalized O.R. and the localized O.R.

The generalized orientation reaction (tonic) is characterized by rapid habituation (usually 10 to 15 trials), E.E.G. rhythms of higher frequency over the entire cerebral cortex and a duration which may last up to an hour. The localized orientation reaction (phasic) in comparison, has a greater resistance to habituation (typically around thirty trials), higher E.E.G. rhythms being present only in the cortical area of the particular sensory modality of the stimulus and not over the whole of the cerebral cortex, and its duration is short usually around a minute.

Berlyne (1960) points out that the generalized O.R. is similar to an overall and lengthier increase in arousal whereas the localized O.R. is similar to shorter and sudden bursts of increase in arousal. He goes further to say:

> The term 'arousal reaction' is usually and most properly applied to the change that turns a sleeping animal into a waking one, whereas the orientation reaction is a process that occurs in an animal that is awake but not at its most alert (p. 95).

Barham (1971) in discussing the available literature, points out that there is very little research concerning the generalized O.R. He suggests that this is due, in part, to our present inability to operationally distinguish between the arousal reaction and a generalized O.R.

The orientation reaction and mental retardation

Some interest has been shown for using the O.R. as a differentiating variable between sub-populations (e.g. mentally retarded, mentally ill, normal). Gamburg (1958) demonstrated that an auditory stimulus elicited consistent O.R.'s in normal subjects whereas the schizophrenics either made a defensive reaction or no response while the feebleminded subjects in almost all cases elicited the defense reaction. Referring to vascular and GSR components of the O.R., Luria (1963) states that "in a significant number of cases, stimuli of low or medium intensity which always evoke the O.R. in normal children are not accompanied by such a reaction in child-oligophrenics" (p. 103). There are a number of studies in which reports of unusual activity of the O.R. in the mentally retarded as compared to the normal are found. Karrer and Clausen (1965) using a G.S.R. measure found that retardates had shorter latency and shorter time to maximum response than normals. The literature also indicates that the habituation rate of the G.S.R. was considerably slower for the retarded as compared to the normal subject (Clausen and Karrer, 1968; Fenz and McCable, 1971; Lobb, 1970). Assuming that pupil dilation is an accepted component of the O.R., it should also provide differentiating characteristics between normals and retardates.

The need for research including the educable mentally retarded child who forms a relatively large proportion of our special school populations and the pupil dilation component of the O.R. is apparent. To the author's knowledge there has been only one piece of research which has evaluated the influence of these variables. Boersma, Wilton, Barham and Muir (1970) studied the pupillary dilation of normals and educable mentally retarded children during arithmetic problem solving tasks. In this study the period of time to solution was divided into equal thirds (vincentized) when analyzing the data, thus giving three repeated measures for each trial. Three classes of task difficulty were built into the problems presented. The authors concluded that:

(a) during the problems designated as hard-difficulty, pupil dilation increased as a positive function of time to solution for normal subjects;

(b) the differences in pupil dilation between normals and retardates was a positive function of time periods to solution, i.e. the difference increased from the first section to the second and third sections of the trials;

(c) greater mean dilation increased positively as a function of problem difficulty.

In addition, certain trends of interest to this present investigation were noted and are as follows:

(a) greater dilation over the total solution period and for all problems were observed for normal subjects;

(b) initial pupillary response over all problems was greater for retarded subjects;

(c) pupillary dilation increased as a positive function of periods for normals, however this pattern appeared for the retarded children only during the low-difficulty problems and to a lesser degree during the medium-difficult problems.

It is evident that there are important discrepancies between the pupil dilation of normals and educable mentally retarded (E.M.R.) children during problem solving, and although the research of Boersma et al. (1970) tends to substantiate present theories concerning the orientation reaction's ability to discriminate normals and E.M.R.'s, it is clear that there are other variables which require investigation. Pupillary dilation as a function of the solving or the not solving of a problem is one of these variables.

Task solution and pupil dilation

Boersma et al. (1970) reported greater dilation for normals than for E.M.R.'s which increased positively as a function of the three periods per trial for solution. In addition, their results showed a typical pattern for both normals and E.M.R.'s of increasing dilation from period one to period three as well as increasing dilation from less to more difficult problems. However, the E.M.R. children did not follow this pattern. During the third period of problem solving, they showed the greatest dilation for the low difficulty problem but the least dilation for high difficulty problems.

The authors give two possible explanations for these unexpected data. The first explanation was based on the possible effects that success and failure might have on the changes in pupil dilation. They suggested that the effects of success or failure would logically be present during the third period of solution. Their inference is that success in solving the problem could be, in part, a factor in increased amounts of dilation. This inference is based on two of their findings. First, normals who solved a much large proportion of the problems showed greater amounts of dilation. Further, it was during the third period that this difference was greatest. Second, during the third period there was greater dilation on low difficulty (where there were more problems solved) as compared to high difficulty problems in contrast to the first and second period for the E.M.R. subjects.

An alternative or second explanation for the unexpected findings with the E.M.R.'s was presented in terms of Berlyne's theory of attention. It would be expected that the construct of arousal would be useful in this case. However, the lack of dilation for high-difficulty problems is incongruent with a theory which would expect increased arousal with increasing difficulty of the problem and therefore increasing pupil dilation.

Boersma et al. (1970) suggested that during the third period the smaller amounts of dilation for high-difficulty problems can possibly be seen as a lack of attentiveness on the part of the E.M.R.'s. In other words, the E.M.R.'s could have given up trying to solve the problem because of its difficulty and were therefore not attentive to the stimulus presented.

The literature reveals little evidence regarding the effects of solving on pupillary dilation. Payne, Parry, and Harasymiw (1968) in a study with normal adults investigated pupil dilation as a function of item difficulty. No correlation was found between the correctness of the response and the percentage of pupil dilation of the subject. Both unsolved single-solution anagram tasks and unsolved arithmetic problems were reported to be associated with a high plateau of maintained dilation (Bradshaw, 1967) suggesting that non-solving per se might result in greater amounts of dilation than solving.

It is clear that further investigation into the effect of success in performance on pupil dilation is needed. New evidence should aid in solving this discrepancy of interpretations which exists between the study of Boersma et al. (1970), (suggesting that solving might be a factor related to increased pupil dilation) and the work of Payne et al. (1968) and Bradshaw (1967) which provide evidence indicating that non-solving could be a factor related to increased pupil dilation.

In summary, a logical basis for the present investigation has been presented. The viewpoint of attempting to disclose the biological malfunctionings of the E.M.R. with the purpose of eventually remedying these malfunctions and thereby helping the retarded to overcome learning problems was favored over considering the retarded as individuals who are lowest on the normal curve with irreversible problems. Attention, assumed to be a prerequisite for learning, was cited as a major problem for the retarded. It was shown, however, that the concept of attention is by no means an easily defined or clearly understood construct. With that knowledge in mind, Berlyne's theory of attention was provided as a framework from which the O.R. can be considered.

An explanation of the O.R. followed illustrating that it includes a number of components, one of which is pupil dilation changes. The O.R. has been speculatively employed to differentiate between subpopulations such as the E.M.R. and normal subjects. It was suggested that if the O.R. of the E.M.R. is malfunctioning, then this problem would have to be overcome in order to provide an optimal learning environment for the E.M.R. child. Boersma et al. (1971) provide supportive evidence for the use of a pupillary dilation measure in differentiating E.M.R.'s and normals during task-related activities. Their results were suggestive in terms of the relationship between task solution and increased pupil dilation.

CHAPTER II

Rationale and Hypothesis

General definitions

Orientation reaction. A reaction which occurs upon the presentation, modification or termination of stimulus enabling the organism to perceive and process information about that stimulus more efficiently. This reaction includes a number of responses involving sense organs, skeletal muscles, electroenceophalogram changes, and vegetative changes.

Component of the orientation reaction. Any one response which is part of the constellation of responses forming the orientation reaction (e.g. pupil dilation, change in heart rate, eye movements).

Anagram. A nonsensical word made from another by rearranging its letters (e.g. COW - OCW).

Response terms

Solution response. The subject indicated that he wished to report a solution before a 30 second solution period was over by closing his eyes. He then told the examiner the word or spelled the word which he had in mind. If a 30 second time period elapsed without this occuring, the examiner asked the subject to report a solution to the anagram. Responses were always accepted in a neutral manner.

Vincentizing. The division of each trial into thirds providing an equal first, second, and third response section for each trial.

Solved anagram. When the subject's reported solution was in fact correct, the anagram was scored as being solved. The subject's belief that a solution was the correct one was not sufficient criterion for that anagram to be scored as a solved anagram.

Unsolved anagram. When the subject's reported solution was not correct, even if he believed that he had successfully arrived at the correct answer.

Pupillary response measures

Periods. There were four periods for each anagram. The first period, a control period, was a three second period immediately prior to a ready signal. The solution time for each anagram from stimulus presentation to eye closure or 30 seconds was divided into three solution periods equal in length for that particular anagram. These three periods provided the pupillary data during problem solving.

Baseline. An exclusive baseline was determined for each of the eight anagrams for every subject. It was derived by adding four graph units to the point of maximum dilation during solution-time. This newly-arrived-at point was then extended back to the control period time and the units from this base to the pupil dilation recordings were computed as the control scores. It was also extended forward to problem termination providing the baseline in computing scores for the three solution periods as well.

Mean change in pupil dilation. The scores were derived by counting the standard graph units from the baseline to the recorded dilation markings at every half second interval during the control period and each of the three solution periods. The scores for a particular period were then averaged giving a mean score for that period. Consequently, each subject had four mean scores computed for every anagram presented. However, the results of the four individual anagrams for the auditory and visual stimuli were combined for purposes of analysis. These mean scores for each of the four periods were consequently averaged over all auditory anagrams and all visual anagrams. For example, the four mean scores of the control periods of the four auditory anagrams were averaged resulting in the mean change in pupil dilation for the control period of all auditory anagrams. The mean change in pupil dilation was calculated in the same fashion for the remaining three solution periods for all auditory anagrams and the control period and the three solution periods for all visual anagrams, resulting in eight mean change scores for each subject. These eight scores were used in the statistical analysis of the research presented.

Rationale

Gamburg (1958) suggests that the O.R. can be used as a discriminator of sub-populations. Luria (1963) more specifically states that retarded children show an O.R. of lesser magnitude than do normal children to stimuli of moderate intensity. This study's stimuli, although not measured, are assumed to be of moderate intensity.

Boersma et al. (1970) provide evidence on the pupillary component of the orientation response, when comparing normal and E.M.R. children during a period of problem solving or higher mental activity. The results of this study show that normals have greater amounts of pupil dilation than do the E.M.R. and that this difference increases as a function of thirds of solution time. More specifically, the first third during solution shows the least difference between the two groups, while the last third shows the greatest difference. The study presented in this paper attempted to examine further the pupillarv component of normal and E.M.R. children during a problem solving period. The use of both auditory and visual stimuli (anagrams) allowed for an assessment of the non-modality specific aspects of the pupillary component of the O.R.

Hypothesis 1.1 Normal children will show greater mean changes in pupil dilation than educable mentally retarded children during problem-solving of auditory anagrams. Further, this difference will be smallest during the first period of the vincentized solution-time and greatest during the third period.

Hypothesis 1.2 Normal children will show greater mean changes in pupil dilation than educable mentally retarded children during problem-solving of visual anagrams. Further, this difference will be smallest during the first period of the vincentized solution-time and greatest during the third period.

Rationale

A discrepancy in results during the third period of solution time for the E.M.R.'s caused Boersma et al. (1970) to consider the effects of success and failure on the pupillary component of the O.R. The discussion of these results implied the possibility that success in solving a problem could be accompanied by an increase in pupil dilation. However, it was noted that the variable of the two sub-populations could be responsible for this implied possible effect of solving as the normals solved significantly more problems than the E.M.R.'s

In order to examine the effects of solution upon pupil dilation, it would be necessary to control the variable of sub-populations. The present investigation was designed to provide such control.

Payne et al. (1968) produced evidence which indicated little correlation between correctness of response and amount of pupil dilation. Bradshaw (1967) reported that unsolved anagrams produced a high plateau of maintained dilation. Taking into account the variables of sub-populations and vincentized solution periods, this study attempted to further examine the effects of solution in relation to pupillary activity.

Hypothesis 2.1 There will be greater mean changes in pupil dilation during the vincentized solution-time when the anagrams have not been solved as compared to when they have been solved, when the variable of sub-populations is controlled on auditory anagrams.

Hypothesis 2.2 There will be greater mean changes in pupil dilation during the vincentized solution-time when the anagrams have not been solved as compared to when they have been solved, when the variable of sub-populations is controlled on visual anagrams.

CHAPTER III

Method

Subjects

Children between the chronological ages of 9 and 12 comprised the sample for this study. The subjects were enrolled in the Edmonton Public School System in either regular or opportunity class settings. The cumulative record cards of each child were supplied and any child suspected of brain dysfunction, organic defects, or severe emotional problems on the basis of these records was not involved in the study. Also, any child not having vision close to the 20/20 visual acuity criterion as measured by the Snellen Chart was not included as the apparatus used will not tolerate the reflection of light from glasses or contact lenses.

A total of 86 children were originally tested, however, 40 subjects were eliminated. These subjects were eliminated for three major reasons. Data which were unscorable because of numerous eye blinks, extraneous movements on the part of the subject, and data which were incomplete were excluded from the sample. Similarly, data, in which one or more latency to response measures were less than one second were eliminated.

The Wechsler Intelligence Scale for Children was administered by qualified personnel in order to obtain each subject's intelligence quotience. The full scale score was used. There were two experimental groups described as educable mentally retarded and normal.

The educable mentally retarded (E.M.R.) were designated as such by two criteria. First, each of these subjects was functioning at a level lower than that expected of their chronological age group in the educational system. They were enrolled in opportunity classes, having been placed there because of an inability to cope with the normal classroom setting. The second consideration was their intelligent quotient, which was considerably less than that of the normal population.

The normal group was designated by their present functioning in the normal classroom setting at the level which is expected of them with respect to their age and grade in school. These children were all within the normal to superior range in intelligence using the Wechsler Intelligence Scale for Children as the reference scale. Table 1 provides a description of these data for all the subject groups.

In order to investigate the effects of solution of a problem on pupil dilation, two additional analyses were carried out; one for auditory anagrams, the other for visual anagrams. Since normals solved more and also had greater increases in pupil dilation, it is difficult to discern which variable -- normality or solution -- is in fact the correlate of increased dilation. Thus, it is necessary to control for the variation of subpopulations when investigating the effects of solution upon pupil dilation. This control was achieved by utilizing only those subjects who had solved some but not all of the anagrams, resulting in a score for each subject under both conditions of solved and not-solved. The subjects, therefore, acted as their own control group.

The auditory subsample consisted of 19 subjects who had solved some but not all of the auditory anagrams. Table 2 provides a description of this subsample with respect to age and I.Q.

TABLE 1

Descriptive Characteristics of the Groups Within the Initial Analysis

Groups	N	CA (yr-mo)		I.Q.	
		Mean	SD	Mean	SD
Educable Mentally Retarded	27	11-1	10.86	69.70	7.18
Normals	19	11-3	8.08	118.47	9.96

TABLE 2

Descriptive Characteristics of the Groups Within the Solver-Non Solver Analysis of Auditory Anagrams

Groups	N	CA (yr-mo)		I.Q.	
		Mean	SD	Mean	SD
Educable Mentally Retarded	14	11-2	11.07	71.85	6.63
Normals	5	11-3	7.45	120.40	12.86

The visual subsample consisted of 25 subjects who had solved some but not all of the visual anagrams. Table 3 provides a description of this subsample with regards to age and I.Q.

Apparatus

The Laboratory was a sound proof room painted black in order to reduce extraneous light. All the equipment needed for the experiment was situated within the laboratory in order to ensure its effective control and manipulation. However, the subject was isolated from the ongoing activities of the experiment by a black curtain which was drawn around the subject's chair. This procedure reduced the number of distracting visual stimuli. The low level of light was kept constant for a minimum of five minutes prior to and during the experimental procedure in order to control for pupillary adaptation to light.

The subject's positioning was insured by several methods. He was seated in a chair which was adjustable in height and made comfortable with foam and padding. Each subject was placed on a bite bar in order to eliminate head movements. The bite bar consisted of a U-shaped instrument which was covered with dental compound in order that teeth impressions could be made and used as a fixed reference point for the subject. A compound heater was used to sterilize and warm the dental compound. The bite bar was securely attached to the apparatus throughout each experimental session.

The pupillary data was obtained with a Polymetric pupillography recorder, Model V-1165, which consisted of three main components. The image transducer photographed the pupil images at the rate of 60 times

TABLE 3

Descriptive Characteristics of the Groups Within the Solver-Non Solver Analysis for Visual Anagrams

Groups	N	CA (yr-mo) Mean	CA (yr-mo) SD	I.Q. Mean	I.Q. SD
Educable Mentally Retarded	19	11-2	12.12	70.42	6.78
Normals	6	11-3	5.50	121.16	4.87

per minute and projected them onto the surface of a video tube. These recordings were then transformed into sequential signals, which were directly proportional to the diameter of the pupil. This transformation was accomplished through the use of a signal analyser. The third component consisted of a Hewlett-Packard Model 681 strip chart recorder which yielded a continuous ink record on chart paper of the electrical signals. In order to obtain an adequate light exposure for the photographing, a near infra red light was used.

A Sony tape recorder (Model TC-77-4J) with a binaural headset and integrated amplifier (Model 1120) was used to produce identical instructions and auditory stimuli to each subject. The instructions for the experiment were recorded prior to administration. The effect of extraneous auditory stimuli was controlled by the use of background white noise of 65 dB intensity. It was produced by a Marietta white noise generator and was then relayed to the headset by the amplifier and tape recorder. A dual track tape was used insuring that the white noise and auditory stimuli would not interfere with each other and they were each presented through both of the earphones.

The auditory anagrams were presented with the earphones, whereas the visual anagrams were presented in a box frame. Each visual anagram was displayed on a card which was exposed by quickly slipping the card into the box frame thereby covering the control stimulus. The visual stimulus was approximately 24 inches from the subject's eyes with slight variations due to the differences in the size of the subject's heads.

Stimulus materials

Eight anagrams were presented to each subject: four visual and four auditory problems. Each anagram was a word chosen from the Lorge-Thorndike word frequency list which consisted of three letters and one solution. All the words were of high frequency (at least 50 occurrences per one million words) as three-letter low-frequency words were very rare and would be too difficult for the educable mentally retarded (E.M.R.) group to solve. Some evidence (Edmonds and Mueller, 1969; Johnson and VanMontfrans, 1965; Mayzner and Tressalt, 1958) has been provided which suggests that low-frequency anagrams are more difficult to solve than high-frequency anagrams. A table of random numbers was used to choose the words which could satisfy the above criterion.

The auditory anagrams (see Appendix A) consisted of the words cow, let, way, and big. Following a ten-second period of white noise, the word "ready" was heard. Two seconds later the letters for each anagram were presented at 1-1/2 second intervals. A maximum solution time of 30 seconds was allowed for each anagram.

The visual anagrams (see Appendix A) consisted of the words put, men, bar, and pen. The instructions were presented through the earphones. There was a ten-second period during which white noise was heard by the subject and a blank white card was looked at. Then, a card with "ready" printed on it was dropped into the viewing screen and approximately two seconds later the anagram which was printed on a white card was dropped into the viewing screen and remained until solution. The maximum solution time for each problem was 30 seconds.

The letters printed with black India ink on a white background were three-eights of an inch in height. The width of the line segments of each letter was one thirty-second of an inch.

Randomization for both the order of presentation of the four anagrams within each sensory modality and for the order of presentation of the two sensory modalities was carried out.

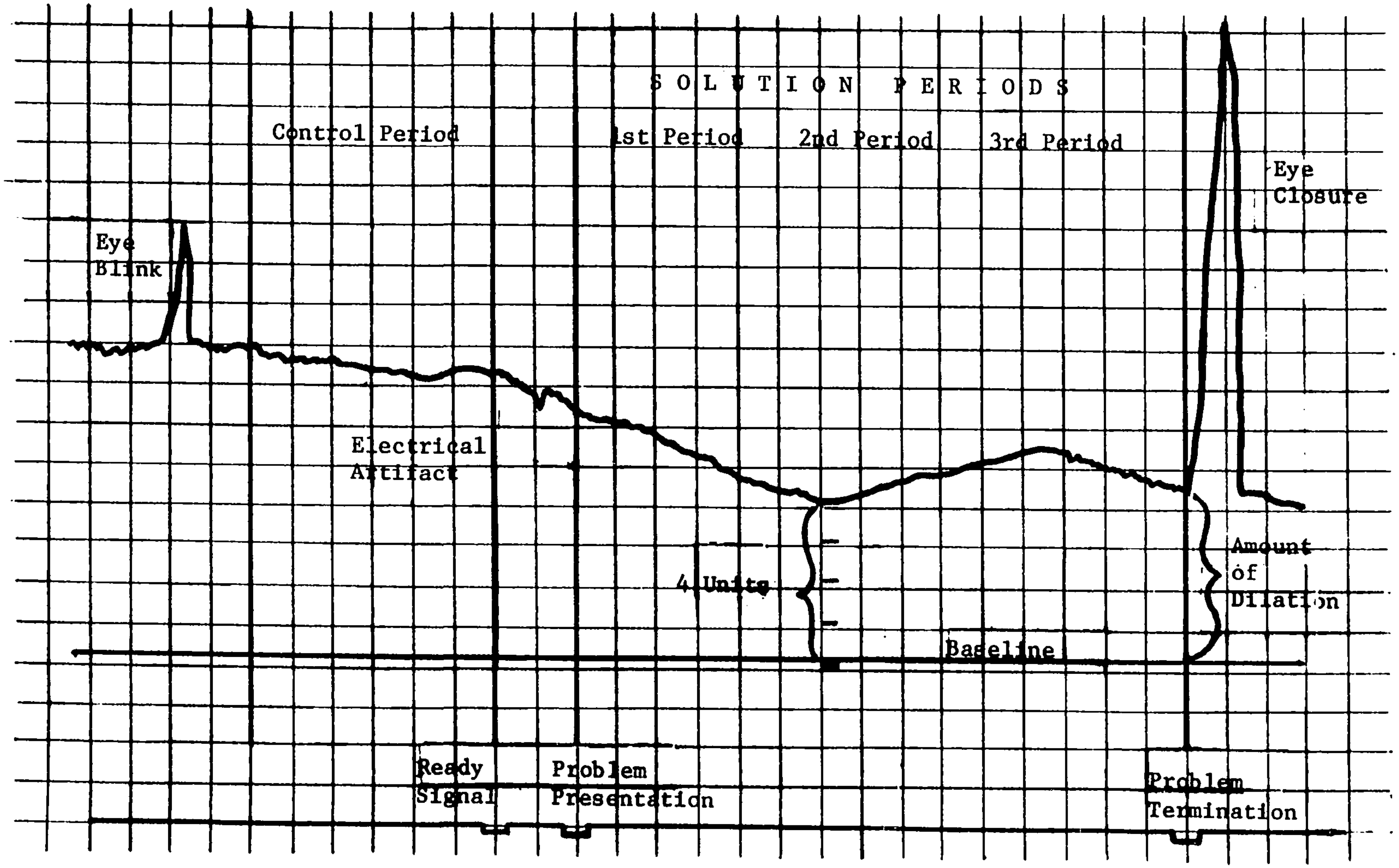
Response measures and scoring procedures

The data were recorded on a continuous strip of graph paper as were the occurrences of the stimulus presentation through the use of an event recorder. The responses for each subject were scored as follows. A baseline was determined by taking the point of maximum dilation between the points of the ready signal and problem termination. Four units were then added in order to insure positive numbers for all scores. This arbitrary point was then extended across the subject's chart for that particular anagram providing the baseline for scoring. Figure 1 presents an example of a typical pupillary response record identifying measurement units. This scoring technique resulted in greater dilation being reflected in a decreasing score since the baseline was _4_ units below the point of maximum dilation.

The half-second intervals for the three second control period preceding the ready signal, and for the solution time to the problem (starting from problem presentation to termination of the problem) were then marked off. The number of units from the baseline to each half-second mark were then calculated. The latency to solution time period was then divided into thirds (vincentized, Woodworth and Scholosberg, 1961, p. 535). The half-second scores for each time period were then averaged giving each subject four average scores for each anagram: one-three-second control period, and 3 periods of solution time.

FIGURE 1

A Typical Pupillary Record
Identifying Measurement Units



Boersma et al. (1970) found that more fruitful analyses resulted from the use of logarithmic transformations of the data than for the raw scores themselves. Since this transformation can provide a correction factor for the skewness of a distribution, as well as reducing heterogeneity of variance, it was employed in the present investigation as well. Consequently, the average dilation scores of the reported data were transformed into log scores for all analyses. These log scores were then utilized by averaging for each of the response periods the respective scores from the four anagrams of each sensory mode.

Procedure

Each subject was tested individually although they were brought to the university from their school in groups of three. The research assistant met the children and took them to the laboratory where she put them at ease and explained the apparatus briefly. One of the subjects was then tested while the other two were either given the WISC or entertained elsewhere in the building. Each child was made comfortable in the chair and then asked to make his dental impression on the bite bar which was prepared prior to each experimental session.

While on the bite bar, the camera and the near infra red light were adjusted for each subject before the actual stimulus presentation. The headset was then made comfortable for the child and he was instructed to listen to the headset for further instructions (see Appendix B). The white noise was then turned on and each subject was presented with an example in order to familiarize him with the experimental procedure. The experimentation was begun using the bite bar to ensure that the subject's positioning was kept constant during each experimental session.

The subject viewed the stimulus with both eyes although only the right was photographed. If the subject reached solution before the 30 second time limit, he was required to shut his eyes indicating problem termination. After the 30 seconds or problem termination (whichever occured first) the subject came off the bite bar in order to tell the experimenter his answer. The subject was allowed to either spell out his answer of just say the word; for example, "It's t-u-p" or for another subject, "The word is put". The answer was recorded and the experimenter acknowledged and accepted the response in a neutral manner. The subject went back onto the bite bar for the presentation of the next stimulus. This procedure was continued for the entire set of anagrams.

The experimentation time for the anagram presentations was approximately twenty minutes for each child.

Design and statistics

Auditory and visual data were analyzed separately throughout the study. Homogeniety of variance tests were calculated for all analysis of variance procedures used in this design.

A 2 x 3 (groups x periods) analysis of variance (Winer, 1962, p. 302) with repeated measures on periods was carried out for both the auditory and visual anagram data. The two groups consisted of educable mentally retarded and normal children with the vincentized solution time providing the three periods for the repeated measure.

Two further analyses were carried out using a 2 x 3 x 2 (groups x periods x solving-not solving) analysis of variance (Winer, 1962, p. 374) separately for both auditory and visual data. The two groups were as above. The periods were the three periods of solution analysed as a repeated measure; and the solving - not solving variable comprised the other repeated measure.

CHAPTER IV

Results

In reading the results of the analysis of the data, it should be recalled that a smaller data score reflected greater pupil dilation. This inversion is due to the adopted scoring technique. It should also be noted that all analyses involved groups of unequal numbers of subjects and data which were logarithmically transformed unless otherwise indicated.

Performance data

Tables 4 and 5 illustrate the performance data by displaying the average number of 1/2 second scores taken to solve a problem and the average number of anagrams (of four) which were correctly solved for both auditory and visual tasks. The results of the t-tests clearly show that the educable mentally retarded (E.M.R.) had a more difficult time with the anagram tasks as they required significantly more time to solve the anagrams (auditory: $t = 21.16$, $df = 44$, $p < 0.01$; visual: $t = 24.11$, $df = 44$, $p < 0.01$) and were successful in solving significantly fewer anagrams than normal subjects (auditory: $t = -33.42$, $df = 44$, $p < 0.01$; visual: $t = -30.50$, $df = 44$, $p < 0.01$). These data clearly substantiate the classification of the subjects into two distinct groups in terms of their functioning during task-oriented activities.

Order effects

Essential to the validity and interpretation of the data was the absence of an order effect (that is, whether the order of stimulus pre-

TABLE 4

Average Number of Half-Second Scores Needed By The Subject to Solve the Four Anagrams

	Auditory	Visual
Educable Mentally Retarded	30.32	26.50
Normal	13.60	8.42

TABLE 5

Average Number of Anagrams (of Four) Correctly Solved for Both Auditory and Visual Stimuli

	Auditory	Visual
Educable Mentally Retarded	1.29	1.85
Normal	3.63	3.68

sentation - auditory anagrams first or visual anagrams first - was an influential factor). Consequently, the mean of the averages of the three response periods over all four anagrams from each modality for both groups and orders (order 1, auditory first; order 2, visual first) was calculated. These results are illustrated in Table 6. There is a tendency for less dilation in order 1 than order 2; however, four t-tests between order 1 and order 2 for normals and E.M.R.'s during auditory or visual stimulus presentation revealed no statistically significant results. It was concluded, therefore, than an order effect was not present.

Hypothesis 1.1

It was hypothesized that normal children would show greater mean changes in pupil dilation during problem solving of auditory anagrams than E.M.R. children with this change increasing positively as a function of periods.

The results of the 2 x 3 (groups x periods) analysis of variance for mean change in pupil dilation with a repeated measure of the periods are reported in Table 7. A main effect for groups ($F = 20.737$, $df = 1$, $p < 0.01$) was significant. From the cell means, it can be seen that normals showed significantly greater mean changes in pupil dilation than did the E.M.R.'s. There was no main effect for periods of solution time nor was the interaction effect between groups and periods significant. Accordingly, hypothesis 1.1 was confirmed in part only; normals showed greater mean changes of pupil dilation than E.M.R.'s, but this change did not increase positively as a function of periods.

TABLE 6

Cell Means for the Averages of the Three Response Periods Over All Four Anagrams For Visual or Auditory Stimulus by Groups and Order

	NORMAL		EDUCABLE RETARDED	
	Auditory Anagram	Visual Anagram	Auditory Anagram	Visual Anagram
Order 1 Auditory First	11.952	11.779	13.989	13.054
Order 2 Visual First	11.543	11.378	13.869	12.536

TABLE 7

Mean Change in Pupillary Dilation
Response and Analysis of Variance
For Groups By Periods for Auditory Stimuli

Cell Means for Pupil Dilation Response for Groups and Three Periods of Solution Time

Groups	N	Period 1	Period 2	Period 3
Educable Mentally Retarded	27	2.608	2.605	2.586
Normal	19	2.462	2.432	2.423

Summary Analysis of Variance

Source	df	Mean Square	F	P
Between Subjects	45			
Groups (a)	1	0.863	20.737	0.004^{-2}
Subjects Within Groups	44	0.042		
Within Subjects	92			
Periods (B)	2	0.010	1.337	0.268
A x B	2	0.002	0.245	0.783
B x Subjects Within Groups	88	0.008		

Figure 2 presents the cell means for the pupil dilation response plotted for groups and periods showing clearly the group differences for all three periods.

Hypothesis 1.2

It was hypothesized that normal children would show greater mean changes in pupil dilation during problem solving of visual anagrams than E.M.R. children with this change increasing positively as a function of periods.

The results of the 2 x 3 (groups x periods) analysis of variance for mean change in pupil dilation are reported in Table 8. A main effect was found for groups ($F = 11.684$, $df = 1$, $p < 0.01$) and periods ($F = 55.643$, $df = 2$, $p < 0.01$). An interaction effect was also found ($F = 6.458$, $df = 2$, $p < 0.01$) requiring further examination for simple effects. The results of the tests for simple effects are displayed in Table 9 and indicate that the difference between the groups during period 1 was not significant ($F = 3.009$, $df = 1$, $p = 0.090$); however, this difference during period 2 was significant at the 5% level ($F = 5.351$, $df = 1$, $p = 0.025$); and during period 3, it was significant at the 1% level ($F = 22.570$, $df = 1$, $F < 0.01$). The Tukey tests (Winer, 1962, p. 102) on periods indicated that for both E.M.R.'s and normals, there was significantly less dilation for period 1 than period 2, and for period 2 than for period 3.

The preceding results clearly confirm hypothesis 1.2 in that normals showed more dilation than E.M.R.'s and this difference increased positively as a function of periods.

FIGURE 2

Graphic Representation of Pupil Dilation Response
For Groups and Periods for Auditory Stimuli

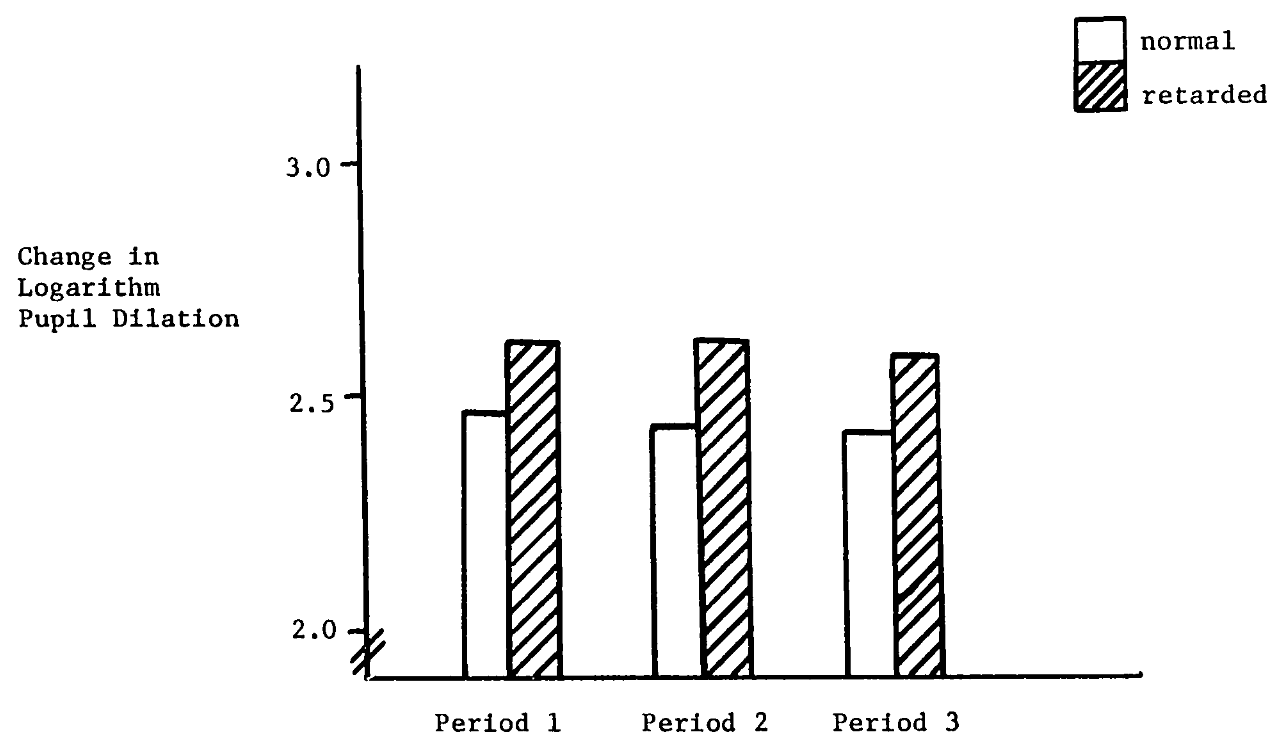


TABLE 8

Mean Change in Pupillary Dilation
Response and Analysis of Variance
For Groups By Periods for Visual Stimuli

Cell Means for Pupil Dilation Response for Groups and Three Periods of Solution Time

Groups	N	Period 1	Period 2	Period 3
Educable Mentally Retarded	27	2.606	2.506	2.486
Normals	19	2.540	2.418	2.305

Summary Analysis of Variance

Source	df	Mean Square	F	P
Between Subjects	45			
Groups (A)	1	0.420	11.684	0.001
Subjects Within Groups	44	0.036		
Within Subjects	92			
Periods (B)	2	0.359	55.643	0.005^{-4}
A x B	2	0.042	6.458	0.002
B x Subjects Within Groups	88	0.006		

TABLE 9

Tests for Simple Effects for Visual Stimuli

Groups at Period 1, Period 2 and Period 3

	Cell Sum For E.M.R.'s	Cell Sum For Normals	MS	F	P
Period 1	70.37	48.26	0.049	3.009	0.090
Period 2	67.67	45.94	0.087	5.351	0.025
Period 3	67.13	43.79	0.368	22.570	0.002^{-2}

Tukey Test Results for Periods at Group 1 (E.M.R.'s) and Group 2 (Normals)

Educable Mentally Retarded	Period 1 sig. < Period 2,	Period 2 sig. < Period 3
Normals	Period 1 sig. < Period 2,	Period 2 sig. < Period 3

Figure 3 presents the cell means for the pupil dilation response plotted for groups and periods. This figure clearly indicates both the difference between groups and the increase in pupil dilation across periods.

Hypothesis 2.1

It was hypothesized that there would be greater mean changes in pupil dilation for unsolved auditory anagrams as compared to solved anagrams utilizing a vincentized solution period and control for the variable of sub-populations.

The results of the 2 x 3 x 2 (groups x periods x solved-not solved) analysis of variance for mean change in pupil dilation, with repeated measures on the periods and solved-not solved variable, are illustrated in Tables 10 and 11. No main effects or interactions were significant indicating that hypothesis 2.1 was not confirmed in any respect.

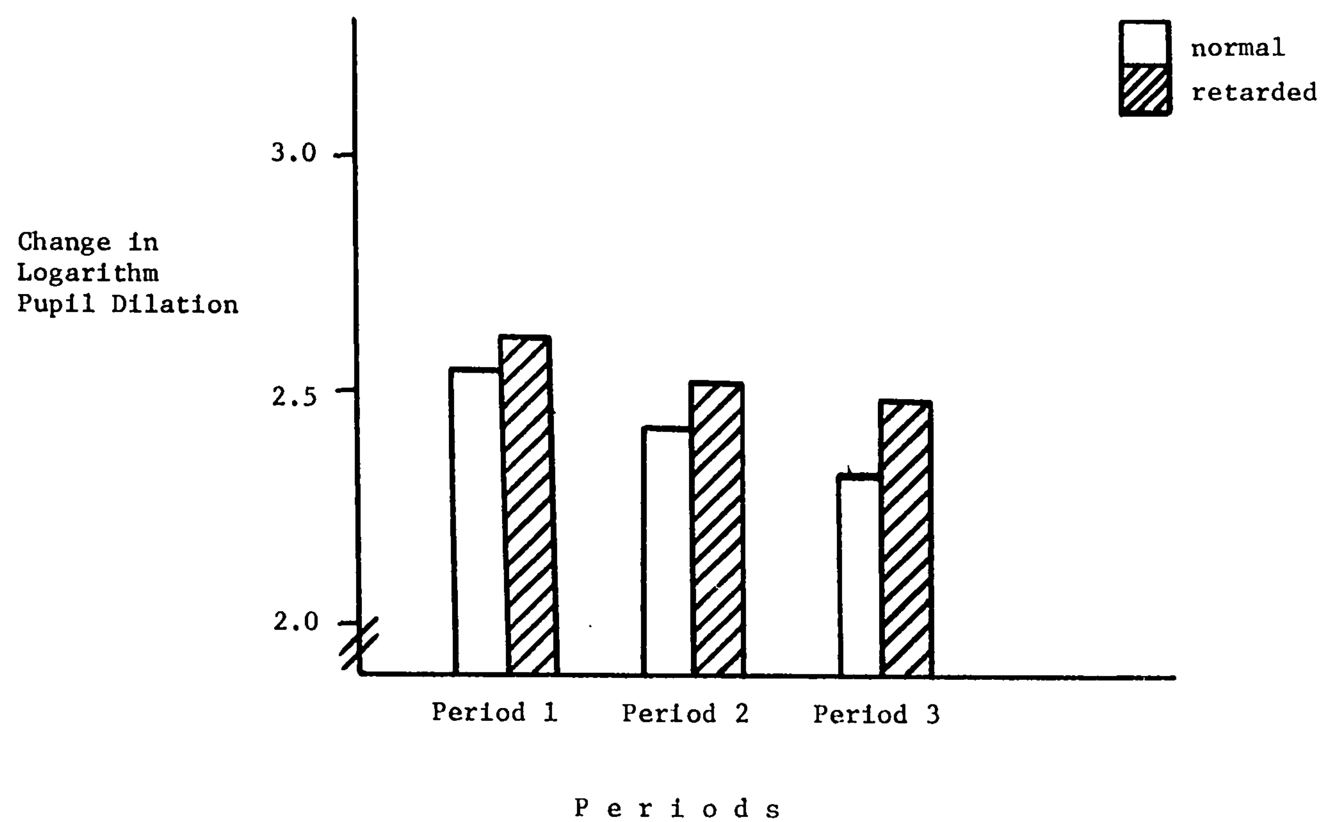
Hypothesis 2.2

It was hypothesized that there would be greater mean changes in pupil dilation for unsolved visual anagrams as compared to solved anagrams utilizing a vincentized solution period and control for the variable of sub-populations.

The results of the 2 x 3 x 2 (groups x periods x solved-not solved) analysis of variance for mean change in pupil dilation, with repeated measures on the periods and solved-not solved variable, are illustrated in Tables 12 and 13.

FIGURE 3

Graphic Representation of Pupil Dilation
Response for Groups and Periods for Visual Stimuli



53

TABLE 10

Cell Means of Pupil Dilation for Groups By
Periods By Solved- Non Solved for Auditory Stimuli

Groups	SOLVED Period 1	SOLVED Period 2	SOLVED Period 3	NOT-SOLVED Period 1	NOT-SOLVED Period 2	NOT-SOLVED Period 3
Educable Mentally Retarded n = 14	2.657	2.601	2.480	2.554	2.596	2.638
Normal n = 5	2.485	2.378	2.471	2.424	2.511	2.546

TABLE 11

Summary of Analysis of Variance of Groups
By Periods By Solved-Not Solved for Auditory Stimulus

Source	df	Mean Square	F	P
Between Subjects	18			
Groups (A)	1	0.309	0.008	>.05
Subjects Within Groups	17	39.416		
Within Subjects	95			
Periods (B)	2	0.000	0.000	>.05
A x B	2	0.026	0.929	>.05
B x Subjects Within Groups	34	0.028		
Solved-Not Solved (C)	1	0.022	0.138	>.05
A x C	1	0.007	0.440	>.05
C x Subject Within Groups	17	0.159		
B x C	2	0.078	2.690	>.05
A x B x C	2	0.022	0.759	>.05
B x C Subjects Within Groups	34	0.029		

The only significant main effect was for periods ($F = 15.667$, $df = 2$, $p < 0.01$). There are no significant interactions. Hypothesis 2.2 was therefore not confirmed. A Tukey test (Winer, p. 102) for the simple main effect on periods was carried out indicating that there was less dilation during period 1 as compared to period 2, and during period 2 as compared to period 3 when the groups and solved-unsolved anagrams were combined. This result was analogous to the periods effect found in the investigation of hypothesis 1.2.

Visual and auditory modalities

The data reported thus far have revealed more fruitful results for visual stimuli than for auditory stimuli. The nature of this difference in data becomes an important factor, however, for the interpretation of results. Many theorists (e.g. Liberman, 1958) consider pupil dilation to be a component of the O.R. and to therefore occur during the stimulation of any analyzer or sensory modality in a non-modality specific manner (i.e. elicited by auditory as well as visual stimuli). The data presented in this investigation would seem, upon superficial examination, to suggest that increases in pupil dilation may be more probable and predictable during visual stimuli and therefore modality-specific in nature. In order to explain this apparent theoretical discrepancy, it was necessary to obtain a measure of the difference in pupil dilation between the control period and period one of exposure to the stimulus (that is, the first vincentized period of solution). Each score was computed by subtracting the value for solution period 1 from the control score. This difference score would be larger with greater dilation.

TABLE 12

Cell Means of Pupil Dilation for Groups
By Periods By Solved-Not Solved for Visual Stimuli

	SOLVED			NOT-SOLVED		
Groups	Period 1	Period 2	Period 3	Period 1	Period 2	Period 3
Educable Mentally Retarded n = 19	2.558	2.477	2.402	2.640	2.537	2.503
Normals n = 6	2.617	2.441	2.303	2.559	2.383	2.433

TABLE 13

Summary of Analysis of Variance of Groups By Periods By Solved-Not Solved for Visual Stimulus

Source	df	Mean Square	F	P
Between Subjects	24			
Groups (A)	1	0.109	0.003	>0.05
Subjects Within Groups	23	37.761		
Within Subjects	125			
Periods (B)	2	0.329	15.667	<0.01
A x B	2	0.018	0.857	>0.05
B x Subjects Within Groups	46	0.021		
Solved-Not Solved (C)	1	0.046	0.667	>0.05
A x C	1	0.046	0.667	>0.05
C x Subject Within Groups	23	0.069		
B x C	2	0.041	2.278	>0.05
A x B x C	2	0.014	0.778	>0.05
B x C Subjects Within Groups	46	0.018		

The basis for analyzing these scores lies in the possibility that the format of presentation of stimuli determines the time course of the O.R., perhaps influencing the present results. That is, the research regarding the non-modality specific nature of the O.R. has, in the main, utilized stimuli such as the short presentation of tones or pictures that are unrelated to the subject's task. These studies have found that the occurance of the pupillary component occurs in a non-modality specific manner to stimuli from differing sensory modalities (Liberman, 1958).

However, another variable may clarify the issue of non-modality specificity of pupil dilation during the presentation of stimuli from different modalities such as auditory and visual anagrams. This variable, the method of presentation, might provide the logical reason underlying the apparent discrepancy between auditory and visual data found in this study. Thus, the non-modality specificity of pupil dilation may be present in this investigation if it can be shown that O.R.'s occur consistently during both sensory modalities, but they differ in timing for auditory as compared to visual stimuli. The differing sensory modalities may not be producing the differing results found in this study but it may be the effects of method of problem presentation under two types of conditions (auditory and visual presentation) which elicit O.R.'s at different points in time.

To examine this possibility the first period was chosen as it seems logical that the solving skills of the individual subject would be relevant during this period for the auditory anagrams but not for the visual anagrams. Hence, auditory stimuli in this study would be expected to produce greater initial amounts of pupil dilation as the subject would be required to be more attentive initially. This phenomenon is so because the stimulus presentation would terminate after 4.5 seconds and therefore it would no longer be available for the subject's sensing. During the presentation of visual stimuli, however, the subject would not need to be as attentive during the initial period since the stimulus would be available to the subject for the entire problem-solving period.

Table 14 illustrates the average difference scores in pupil dilation across all 4 anagrams of each sensory mode. T-tests were calculated for the differences in means between auditory and visual stimuli within the groups resulting in two effects. For both E.M.R.'s ($t = 2.49$, df - 52, $p < 0.01$) and normals ($t = 5.50$, df = 36, $p < -.01$) there were significant differences between auditory and visual data when analyzing the change in pupil dilation utilizing this difference score. Thus, auditory stimuli produced more change in dilation than visual stimuli during the first third of the solution period. Therefore, although the data for visual anagrams indicated apparently consistent effects in terms of pupil dilation, the effect of the auditory tasks during the first period of solution lends support to the non-modality specific nature of the pupillary response as an index of the O.R.

TABLE 14

Cell Means for the Average Difference Scores Between Contr·l and First Periods for Groups by Sensory Mode

	Auditory	Visual
Educable Mentally Retarded	3.70	1.66
Normal	6.65	0.67

CHAPTER V

Discussion

Normal-retarded differences and the period effect

The results of this study provide further justification for the possible use of the pupillary component of the O.R. as a discriminating variable between normal and E.M.R. children during problem solving activities and under controlled experimental conditions. This finding lends support to previous findings of Boersma et al. (1970) and Luria (1963) who both propose that the O.R. of the retarded is of an unusual nature. More specifically, the results of this study expand the knowledge about the occurence of the pupillary dilation response during auditory and visual anagram solution.

In accordance with the position adhered to by this research, this study has dealt with a physiological measure in an attempt to disclose some of the responsible causes of the E.M.R.'s inadequate performance in learning situations. A discrepancy in the elicitation of the pupillary response between E.M.R's and normals has been found in this research providing more data towards the understanding of the underlying factors of the E.M.R.'s learning problems.

Hence, these results suggest that at least part of the E.M.R.'s problem may be that of an ineffective or abnormal O.R. in so far as the pupillary measure is a component of the O.R. As suggested previously, this deficit will have to be better understood and then probably counteracted in order for the E.M.R.'s to reach their optimal level of attention.

The physiological results of this research provide tentative support for some of the theoretical propositions set forth for the understanding of the E.M.R.'s learning process. Berlyne (1960) has suggested that the pupillary component of the O.R. is an exploratory response which subserves the process of selective attention. These results would suggest, therefore, that the exploratory responses in the E.M.R. are deficient perhaps reflecting an inadequate process of selective attention. The deficit in attention which has been cited as the retarded's problem in learning by Denny (1964), O'Conner and Hemmelin (1963), and Zeaman and House (1963) may consequently be explained as stemming at least in part from this deficient exploratory response. In summary, this data suggests that the attention deficit of the retarded can be speculatively examined in terms of a defective exploratory response, which is subservient to selective attention and is caused, at least in part by a defective O.R. as measured by one of its components, pupil dilation.

Although the first part of hypothesis 1.1 and 1.2 was fully confirmed (normals showing more dilation than E.M.R.'s) the second part was only confirmed for visual data (this difference between groups being least during the first period and greatest during the last period). At least for visual data, these results suggest that the functioning of the pupillary dilation component of the O.R. increasingly differs between normals and E.M.R.'s as a positive function of vincentized periods of solution time. Without much further investigation, the theoretical implications of such data are once more purely speculative. However, in pursuing Berlyne's reasoning on attention and the subservient exploratory responses this increasing difference between normals and E.M.R.'s may be viewed as occuring because of assumed increasing adaptiveness of the normals' exploratory responses in becoming more sensitive to the relevant stimuli of the visual task situation. The theoretical interpretation of the increased O.R. as an increase in sensitivity to visual task relevant stimuli on the part of the normals is also upheld by the performance data in that normals were in fact more successful in solving the anagram problems. Their greater success was illustrated not only by their greater number of correct answers than the E.M.R.'s but also by the fact that it took them less time to arrive at a solution.

A simple main effect for periods was an interesting outcome during the analysis of hypothesis 1.2. This period effect revealed that for visual anagrams, period three showed more dilation than period two which showed more dilation than period one for both E.M.R.'s and normals. In keeping with these results, it was found that the only significant variable in the analyses of hypotheses 2.1 and 2.2 was for periods with visual anagrams. The analysis of this simple main effect for periods revealed the exact results as found in the analysis of the simple main effect for periods in hypothesis 1.2.

This period effect found in the analysis of hypotheses 1.2 and 2.2 is suggestive of an orderly mental process of problem solving which occurs for both E.M.R.'s and normals during visually presented stimuli, although the data comparing groups suggest that in E.M.R.'s it is a less effective or efficient process. The ability to use the

O.R. to identify this process physiologically becomes more credible when the scoring technique of this study is kept in mind. Because the solution period was vincentized into thirds, the data can be interpreted to mean that the subject who took three seconds to complete the task and the subject who spent thirty seconds to complete the task appeared to have undergone a similar type of cognitive process as measured by the pupillary response. These data would suggest that for visual stimuli an enhancement of exploratory responses is related to the proximity of the subject to solution of the task as indicated by the increase in pupil dilation as a positive function of periods. This finding is consistent with that of Boersma et al. (1970). However, such an interpretation is a matter of conjecture and requires extensive further research to be accepted and more clearly understood.

Auditory and visual data

The lack of consistency of data between auditory and visual stimuli as illustrated by the period effect for visual data but its absence for auditory data, was an unexpected result. Liberman (1958) states that the pupillary component of the O.R. is non-specific in terms of stimulus modality and in fact could not be considered part of the O.R. if it were not. The auditory data has revealed less fruitful analysis than the visual data throughout the study. Hypothesis 1.1 was only upheld in part, whereas hypothesis 1.2 was upheld totally. Likewise hypothesis 2.1 revealed no effects whereas hypothesis 2.2 revealed a period effect. The necessary explanation of this inconsistency may be found in examining the method of presenting the auditory anagram and the results obtained when looking at the difference scores in pupil dilation between the control period and the first vincentized period of solution time for both modalities. This difference score was in essence measuring the initial O.R. of the subject to stimulus presentation and it was found that the auditory stimulus produced a greater initial O.R. than did the visual stimulus.

In explaining the rationale for using the above investigation to explain differences between the results of auditory and visual data found in this research, it was suggested in Chapter 4 that the different method of problem presentation may have resulted in differing problem-solving approaches being utilized by the subjects in solving auditory as compared to visual problems. Additionally, it was suggested that this differing problem solving approach accounted for the differences in data between the two sensory modalities thereby reducing the possibility that it was a product of modality specificity of the pupillary component of the O.R. It was suggested that if the method of presentation was involved as a variable in the reported results, then period one would show greater increases in pupil dilation for auditory as compared to visual stimuli as the subject would be required to be more attentive during auditory anagrams. If the subject was not as attentive as he should be during the presentation of auditory anagrams he likely would not know what letters were presented to him and would therefore have no chance of solving the problem. But during visual anagrams, the problem solving could differ in that the stimulus is present during the whole solution time. The subject does not, therefore, have to be as attentive during the initial presentation of visual anagrams

and would show lesser initial amounts of O.R. than auditorally presented anagrams as measured by the difference score between control period and first vincentized period of solution time. This interpretation was indeed supported by the result of the control period - period one analysis.

In summarizing the above discussion on the differing results between auditory and visual data, it was suggested that this difference was due not to a modality specificity of the pupillary dilation component of the O.R., but to differing formats of presentation for auditory as compared to visual anagrams which resulted in differing approaches utilized by the subject in order to solve the problems. This differing approach was illustrated by the greater initial amounts of pupil dilation during auditory anagrams when the stimilus presentation was available for only that short period of time as compared to that of visual anagrams when the stimuli were available throughout the problem solving periods. This interpretation requires further clarification and points out the need for research utilizing both auditory and visual problem-solving tasks which are presented in the same manner. If they were presented in the same manner (perhaps the visual anagrams being presented, as were the auditory anagrams, a letter at a time and then covered immediately after presentation) then the suggested variable of differing problem-solving approaches involving varying degrees of attention for differing types of problem presentation could be controlled. This control would enable the researcher to see if in fact the differences found in the pupillary response as compared to visual anagrams was due to inadequate research design as is being suggested. Until further study, the results of this investigation speculatively agree with the theoretically accepted non-modality specific characteristic of the pupillary component of the O.R.

Solving versus the non-solving outcomes

The two hypothesis predicting greater mean changes in pupil dilation for unsolved anagrams as compared to solved anagrams for both auditory and visual stimuli were not upheld. This finding suggests that the solving or non-solving of a problem is not the variable which produces increased O.R.'s for either normals or E.M.R.'s even though normals in general do more solving and at the same time have greater amounts of pupil dilation. The increased amounts of pupil dilation must therefore be dependent on another variable. The results of hypotheses 1.1 and 1.2 suggest that this variable would be a more effective exploratory response (based on Berlyne's theory of attention, 1960) on the part of the normal subject. The interpretation coincides with the basic position that the mentally retarded are in some way physiologically unique and not just at the bottom of the bell curve of normal development. Boersma et al. (1970) in trying to explain an unexpected result of a drop in pupil dilation for the E.M.R.'s during arithmetic solving had suggested that perhaps greater solving on the part of the normals was at least in part the cause of their showing greater amounts of dilation than the E.M.R.'s during the third period. The results of this study did not support this interpretation in that there was no significant change in pupil dilation between solving and non-solving for both E.M.R.'s and normals. These results also do not substantiate Bradshaw's findings that unsolved anagram and arithmetic tasks produce a high plateau of maintained dilation. The discrepancy of results between Bradshaw's research and this present investigation may be due to two variables in particular. Because it is not stated in the publication it is assumed that Bradshaw's subjects were normal adults, and since this study is concerning normal and E.M.R. children, the two studies may not be comparable in terms of the mental development. But of more importance, the definitions of solved and not solved used in the two studies may be different. Although it is not clearly stated, Bradshaw appeared to score as solved the reported solution of the subject regardless of whether that proposed solution was in fact correct. This study only scored as solved those proposed solutions which were in fact correct and so this discrepancy in terminology might mean that the two studies are in essence not comparable.

The lack of significant differences in pupil dilation between E.M.R.'s and normals in the analyses of hypotheses 2.1 and 2.2 seems incongruous with the results of hypotheses 1.1 and 1.2. However, these results are more easily understood when considering the makeup of the samples in the analysis of hypotheses 2.1 and 2.2. The two extremes of the initial samples (that is, those who were very functionally retarded in that they did not solve any anagrams and those who had solved all of the problems) were dropped, leaving only those subjects who obtained at least one correct and at most three correct solutions for a modality specific series. Even though there were still two groups, these groups were much more similar in their ability to perform. Also, the size of the samples was depleted in these analyses.

Referring once again to the speculative interpretation of the results in terms of Berlyne's attention theory, it is suggested that perhaps these two groups (utilized in the solved-non solved analysis) were more similar in their exploratory response processes as illustrated by the lack of differing amounts of pupil dilation and the analogous similarity found between the two groups in actual successful performance.

In summarizing the discussions presented, it is noted that the conclusions presented require further research until they can be more fully supported. With this in mind, however, it can be said that this research has resulted in two tentative and basic conclusions. First, normals appear to show more pupil dilation than E.M.R's during both auditory and visual anagrams. Second, the actual solving or non-solving of anagram problems does not appear to be a signficant variable affecting the amounts of dilation measured for either E.M.R.'s or normals.

CHAPTER VI

Implications and Summary

Implications

The most realistic implication of this study lies in the optimistic future for further research in the area of the O.R. and its usefulness in evaluating the learning process of the E.M.R. and normal child. These results indicate that the suggestions of experts in the area regarding the abnormal O.R. as manifested in the pupillary response of the E M.R. seem to be correct. It seems clear, however, that further research will not be futile but will eventually provide at least some of the answers to the unknown variables involved in the learning process and attention mechanisms.

The pragmatic researcher would perhaps develop no further implications from the presented study. If, however, this research indicates an accurate picture (i.e. that E.M.R.'s show abnormal and malfunctioning O.R.'s during problem solving tasks and that O.R.'s are directly related to attention) then the discovery of the extent and nature of these abnormal O.R.'s is possible. With this knowledge, it would seem likely that the situation could be remedied through at least two possible means.

The first could be by the control of the O.R. through the manipulation of the external environment in the educational setting. The results of this research involving the discrepancy between auditory and visual stimuli is possibly an example of facts which could be useful in the setting up of efficient and effective learning environments. These results indicated that the possible explanation for this apparent sensory specificity was in fact not a modality specificity but a problem of research design involving differing formats of stimulus presentation. The lasting visual stimulus produced more correct responses in less time than did the fleeting auditory stimulus. These data may be illustrating physiologically what educators have known for a long time; that is, a lengthier presentation of stimulus materials is more effective in a learning situation than a fleeting or more hasty presentation of those same materials. In other words, the development of teaching methods which would control and influence the occurrence of the O.R. to relevant stimuli might be accomplished once the nature of the O.R. during the learning process is better understood. This knowledge is very helpful to education, not only in the classes of the E.M.R. but to all our educational systems. It would indicate that teachers could more aptly be able to direct the attentional processes of the child in such a way as to increase his ability to learn.

The second means of influencing or controlling the abnormal O.R. of the retarded might be through medical or neurological interventions. Since the O.R. is a measurable reaction then it should eventually be physically controllable.

Summary

In keeping with the point of view of discovering the physiological causes in the defective learning ability of the E.M.R. child, this study was an investigation of the occurrence of the pupillary component of the O.R. during both auditory and visual three letter anagrams, for both normal and E.M.R. children. In concurrance with previous research, it was found that normals showed more dilation than the E.M.R. children. This finding was interpreted within Berlyne's theory of attention which views increased pupil dilation as an enhanced exploratory response to external stimuli, in turn increasing the attention of the subject to the stimulus material. Thus, the results of this study would indicate that normals show greater and more efficient exploratory responses (which would indicate more effective attentional processes) as measured by both the increased O.R. and the greater number of correct responses produced in shorter time periods.

From previous research (Boersma et al., 1970) it has been suggested that the variable of correct solution might be a factor influencing the occurance of the O.R. In this study, an attempt to investigate this possibility was made by assessing the effect of actually solving or not solving either auditory or visual anagrams. For both groups, this variable did not provide significant effects. This result would suggest therefore that the outcomes obtained here and in the work of Boersma et al. (1970) can be interpreted even more strongly in terms of differences in the occurance of the O.R. as a function of differences between the E.M.R.'s and the normals and not as a function of the solving or not solving of the problem.

An important implication of these results lies in the fruitfulness of future research. It seems clear that there are underlying factors of attention and the learning process for both the E.M.R. and the normal child to be uncovered by further research into the O.R.

It seems very important to determine if these underlying factors may eventually provide educators with knowledge regarding the provision of learning environments which are effective in overcoming the attentional deficits of the E.M.R. child.

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APPENDIX A

Anagram Problems

ANAGRAM PROBLEMS

Auditory Problems

1. a--y--w (way)
2. o--c--w (cow)
3. t--l--e (let)
4. e--g--b (beg)

Visual Problems

		e		
1.	n		m	(men)
		p		
2.	u		t	(put)
		b		
3.	r		a	(bar)
		e		
4.	n		p	(pen)

APPENDIX B

Task Instructions Given to Subjects

Task Instructions Given to Subjects

Auditory Anagrams

Prior to the instructions, each subject was given two examples to demonstrate the task. The examples for the auditory anagrams were: y--o--b (boy), and r--a--c (car).

"Now we are going to play that word game again, but I want you to sit very still this time while we play it. I am going to tell you the mixed-up letters over these earphones, and you must listen very carefully to hear them. Then see if you can make a word you know out of them. Close your eyes as soon as you have the word. Did you understand the game? Let me tell you again. Sit very still. Listen carefully for the mixed-up letters. Try to make a word you know out of them. Then close your eyes as soon as you have the word. Right. Let's try it."

Visual Anagrams

Prior to the instructions, each subject was given two examples to demonstrate the task. The examples for the visual anagrams were: y o b (boy) and r a c (car).

"Now we are going to play that word game again, but I want you to sit very still this time while we play it. I am going to put the mixed-up letters on the screen, and you see if you can make a word you know out of them. Try as hard as you can, and as soon as you have found the word, close your eyes. Got the idea? Sit very still. Look at the mixed-up letters. Make a word you know out of them, and as soon as you have got the word, close your eyes. Let's start now."

END OF REEL