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ABSTRACT

The research paradigm of Farley and Manske on individual differences in the orienting response (OR) defined by heart rate (HR) deceleration was extended to performance in reading readiness tasks. The OR was measured in 114 kindergarteners. Fifteen trials of pure tone stimulation (1000 cps, 61 db) followed by a 16th trial at 2000 cps and a light-off stimulus were presented. The ORs to the initial, 16th and light-off trials were used in the analysis. A baseline-free measure of HR deceleration was employed. Reading-related tasks were the Metropolitan Readiness Tests and the de Hirsch battery. Principal components solution and normal varimax rotation indicated some contribution of the OR to the reading related tasks, though this was markedly moderated by sex. (Author)

Working Paper No. 94

READING READINESS AND EARLY LINGUISTIC SKILLS AS A FUNCTION OF INDIVIDUAL DIFFERENCES IN THE ORIENTING RESPONSE

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Report from the Project on Motivation and Individual Differences in Learning and Retention

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STATEMENT OF FOCUS

The Wisconsin Research and Development Center for Cognitive Learning focuses on contributing to a better understanding of cognitive learning by children and youth and to the improvement of related educational practices. The strategy for research and development is comprehensive. It includes basic research to generate new knowledge about the conditions and processes of learning and about the processes of instruction, and the subsequent development of research-based instructional materials, many of which are designed for use by teachers and others for use by students. These materials are tested and refined in school settings. Throughout these operations behavioral scientists, curriculum experts, academic scholars, and school people interact, insuring that the results of Center activities are based soundly on knowledge of subject matter and cognitive learning and that they are applied to the improvement of educational practice.

This Working Paper is from the Motivation and Individual Differences in Learning and Retention Project in Program 1, Conditions and Processes of Learning. General objectives of the Program are to generate knowledge about concept learning and cognitive skills, to synthesize existing knowledge and develop general taxonomies, models, or theories of cognitive learning, and to utilize the knowledge in the development of curriculum materials and procedures. Contributing to these Program objectives, this project has these objectives: to determine the developmental role of individual differences and motivation-attention in the learning and memory process and to ascertain at what age certain individual differences become important in learning and memory and at what age certain motivation-retention relationships emerge; to develop a theory of individual differences and motivation in learning and memory; and to develop practical means, based on the knowledge generated by the research, as well as synthesized from other sources, to maximize the retention of verbal material.

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Abstract

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I

INTRODUCTION

Reading readiness and early linguistic skills

The United States prides itself as being a literate nation but it has been indicated that as many as one-third of the children in a typical elementary school are one or more years retarded in reading (Harris, 1961). What does this mean in terms of the school careers of these children? Panther (1967) has pointed out that how well a child learns to read in the primary grades affects much of his future school achievement because the child who is a retarded reader is at an increasingly greater disadvantage as he moves into the upper grades. In the intermediate grades, the children must increasingly depend on their reading skills to help them in mastering all subject areas.

An emotional factor often accompanies, and tends to worsen, the retarded reader's problems in coping with his school work. The child may develop feelings of inadequacy and a negative self-concept that leave him feeling less able than ever to keep up with the academic achievements of his classmates.

Interest began to be directed in the 1920's at going back to what seemed to be the source of the difficulty encountered by many children in learning how to read: mounting evidence seemed to point to the fact that reading failure resulted from instruction of beginners without regard to their maturity and background for learning to work with printed symbols (Hildreth, 1958). The first formal suggestion that reading instruction be preceded by prereading activities was made in the 24th Yearbook of the National Society for the Study of Education, published in 1925. This publication suggested that a formal period of readiness work would help many children who otherwise would face difficulties in learning to read (Hildreth, 1958).

Many psychologists and educators agree that the concept of readiness is a helpful and a necessary one [for a dissenting view, see Bruner (1960)], though little agreement can be found on what the concept entails. Ausubel (1959) has suggested that the difficulty in agreeing upon a definition of readiness arises when the concept of readiness is confused with that of maturation, and both are equated with a process of internal ripening. He argues, "Maturation is not the same as readiness but is merely one of the two principal factors (the other being learning) that contribute to or determine the organism's readiness to cope with new experience" (Ausubel, 1959, p. 247). Brenner (1967) has stated this somewhat differently in suggesting, "Readiness is always a state of development produced by hereditary factors which are transformed, or better, transacted through an individual's life experiences, to a unique, organic system that allows functioning and performing of specific tasks."

Russell (1961) has summarized the following ways in which people have regarded readiness: as an expression of interest or purpose, a general maturation, a maturation in a specific matter, or as an ability developed during educational experiences.

Before leaving the general concept of readiness for a concern with some of the specific factors that are believed to contribute to <u>reading</u> readiness, it may be helpful to take a look at the final goals of reading instruction. The teaching of reading has two main goals: learning to recognize printed symbols and obtaining meaning from these symbols. The first part, learning to recognize printed symbols, requires the child to learn to associate the visual stimulus with his response to the sound of it (Anderson & Dearborn, 1965). A child may be said to have learned to read a word when he makes the physical, mental, and emotional responses to the printed word that he would make upon hearing the word spoken aloud.

Understanding of what has been read comes from fusing the meaning of single words into a sequence of meaning. Reading is thus a combination of the recognition of words and the thought processes that are generated by these words (Buswell, 1965). The educators who use the concept of reading readiness have found that the beginning reader needs skills that will allow him to master both parts of the reading process.

Reading readiness has been defined in as many ways as has the more general concept of readiness; certainly most educators who are concerned with the teaching of reading have offered their own definitions (Bond & Wagner, 1966; Durkin, 1966; de Hirsch, 1963; Monroe, 1967; Russell, 1961; Spache, 1963). Spache's definition can be used as an illustrative one: a state or period in the child's development at which he is ready to learn to read with success and satisfaction (Spache, 1963, p. 1). Readiness is not thought of as a unitary trait; it is composed of many factors, and it is possible for a child to be grossly deficient in some of these factors and still be average or above average in his attainment in some of the others. The period of developing readiness for reading will be a transitional one for the child, often stretching over a period of many months.

Spache (1963) has said that a majority of the factors influencing the child's readiness must be favorable before he can be expected to learn to read with success. Bond and Wagner (1966) have offered the following as a list of the necessary readiness traits which must be developed by the child before learning can proceed:

A. Mental readiness

B. Physical readiness

1. Absence of visual difficulties
2. Absence of visual discrimination defects
3. Absence of auditory defects.
4. Absence of auditory discrimination defects
5. Absence of speech defects
6. Accuracy of speech patterns
7. Health factors
8. Absence of neurological limitations

C. Social and emotional readiness

D. Educational readiness

1. Picture Interpretation
2. Orientation to the printed page
3. Background of understanding

4. Extent of vocabulary
5. Quality of spoken language
6. Ability to attend
7. Ability to sense a sequence of ideas
8. Ability to follow directions
9. Ability to handle equipment
10. Desire to read

Others have found additional factors to be important. Monroe (1967) found that the child needs to establish left-right directionality in order to be able to correctly follow the sequence of words in a sentence. Birch and Belmont (1964) studied a population of retarded readers and found that they were significantly less able to integrate visual and auditory stimuli than were normal readers. They suggested that learning to read requires the ability to transform temporally-distributed auditory patterns into spatially-distributed ones; therefore, an inability to integrate stimuli from the auditory and visual modalitites may well be a cause of some cases of reading failure.

In a study by Shea (1968), the ability to make visual descriminations was emphasized as an important factor in learning to read. Retarded readers were found to have a marked inability to visually discriminate among words. De Hirsch has also pointed to the need for making such discriminations in noting, "Both word and letter configurations are probably grasped on the basis of their determining features. Certain readers may tend to the apperception of larger Gestalten, but even if they grasp them more or less as a whole they must still be able to quickly and reliably analyze them into their elements" (de Hirsch, 1963, p. 282).

The child must also be able to make auditory discriminations between words. The development of reading readiness in most kindergartens and first grades requires the child to listen for similar sounds or rhyming words before he is presented the words visually.

The skills needed for reading readiness can be broken down more sharply than is indicated in the list offered by Bond and Wagner (1966). Russell (1948) has suggested the following abilities as prerequisite for the child to be able to profit from the school's introduction of reading instruction: to understand spoken words and to speak them; to guess unfamiliar words from spoken contexts; to follow the cumulative development of a story; to study and interpret pictures, such as those used in primers; to acquire skill in perceiving small objects, such as printed words; to identify component sounds of words, such as rhymes; to attend to directions; to recognize colors; to handle crayons, chalk, and shears; to turn pages in books; to feel a keen interest in printed words and in the ability to read them; and to adopt a "thought-getting" attitude toward selections read to him.

Let us focus on the phrase "to attend to directions." The ability to attend to directions or to the ongoing process of learning to read is important in two ways: without this ability the child cannot respond to what the teacher expects of him in learning to read, nor can he take the readiness tests which would give his teacher an idea of where his deficiencies lie (Bond & Wagner, 1966).

Bond and Wagner have found, as one might expect, that the degree of attending differs markedly among children. Their study revealed that the poorer the attentional habits of the child, the greater will distractions affect learning; all types of learning, including reading, will be influenced. Their study also stressed the importance of attention to the sounds of words and to likenesses and differences in the appearance of words.

Samuels (1967) has found that the ability of the individual to withhold attention selectively from irrelevant and distracting background stimulation seems to be implicated in reading disability. De Hirsch, Jansey, and Langford (1966) also have reported a connection between the processes of auditory and visual discrimination and those of attention. They stated that disabled readers fail because they have difficulties with the decoding and encoding of verbal symbols; one hypothesis may be that they do not pay attention to information fed through auditory pathways; they hear, but they do not necessarily understand.

Santastefano, Rutledge, and Randall (1965) reported an interesting study which explored whether the cognitive functioning of children with reading disabilities could be differentiated in terms of particular cognitive principles. Of the principles they investigated, the only cognitive style which could be implicated in reading disability was the manner in which the child operated when faced with distracting and contradictory background information. The study suggested that a cognitive mechanism crucial for reading is one concerned with processing information in the context of distractions and with an individual's ability to withhold attention selectively from irrelevant and intrusive information.

Once the factors involved in reading readiness are identified, how do the schools go about identifying the children who may be deficient in these skills? Austin and Morrison (1963), in a large-scale national survey, found that the following techniques are most widely used for evaluating a child's readiness for successful experiences in the first stages of reading: teacher observation, standardized and informal tests, checklists of skills, and parent-teacher conferences.

Teachers probably put most stock in their own observations of a pupil's readiness. Honig (1946), in a study that measured the accuracy of such teacher observations against a standardized readiness instrument, the Lee-Clark Reading Readiness Test (1931), found that teachers' forecasts had just as high a degree of predictive value as did the test.

Austin and Morrison (1963) reported that more than 80% of the schools in their study reported that they "always" or "often" used formal readiness tests. These tests were usually given at the end of kindergarten or the beginning of the first grade. Spache (1963) has called these formal reading readiness tests, which include the Metropolitan (1965), the Gates (1942), the Harrison-Stroud (1956), and the Lee-Clark (1951), primarily tests of <u>educational readiness</u> or <u>prereading skills</u>. They usually include subtests on word matching, rhyming, reading and copying letters and numbers, word and picture concepts, and others.

One of the most widely used tests has been the Metropolitan Readiness Test (Hildreth, Griffiths, & McGauvran, 1965). This instrument was devised to measure the degree to which kindergartners or first graders have developed the skills which will enable them to profit by the instruction that occurs in the first grade. The definition of reading readiness which underlies the test is that of "the attainment of a sufficient degree of maturity, proficiency, or skill in a variety of abilities, all of which have a part to play in facilitating the child's successful progress through the work of the first grade" (Hildreth, Griffiths, & McGauvran, 1965, p. 11). The manual which accompanies the test identifies the following as the characteristics which are most crucial to successfully handling first-grade work, and are the qualities supposedly tapped by the subtests of the Metropolitan: comprehension and use of oral language, visual perception and discrimination, auditory discrimination, richness of verbal concepts, general mental ability, the capacity to infer and to reason, knowledge of numerical and quantitative relationships, sensory-motor abilities of the kind represented in handwriting and in drawing, and adequate attentiveness, the ability to sit quietly, to listen, and to follow directions.

Six subtests are included in The Metropolitan: Word Meaning--the pupil selects from three pictures the one that illustrates the word the examiner names; Listening--the pupil is required to select from three pictures the one which portrays a situation or event which the exam describes; Matching--a test of visual perception involving the recognition of similarities; Alphabet--requires the recognition of lower-case letters; Numbers--a test of number knowledge; Copying--measures a combination of visual perception and motor control. The test manual reports that the intercorrelations among the subtests range from .36 to .64. Where reliability estimates are concerned, the odd-even coefficients, corrected by the Spearman-Brown formula, have ranges from .33 to .87 on the subtests and from .91 to .94 on the total test. Robinson (1966) reported a stability estimate for the total test over 12 weeks to be .948 for average pupils, .907 for disadvantaged pupils, and .828 for advantaged pupils.

The value of readiness tests for teachers and other educators lies in the fact that they may yield helpful information concerning the child's future achievement. In a study by Hildreth (1950) that matched pupils' scores on the Metropolitan Readiness Test and the Metropolitan Achievement Test, the correlation coefficient between readiness and total achievement was reported to be .786, while that between readiness and the total reading score was .790. A similar correlational study by Mitchell (1962) between the two tests found correlations that ranged, among various subtests, from .51 to .63. Bagford (1968) looked at the relation between Metropolitan Readiness subtest scores and those on the Iowa Tests of Basic Skills and reported that correlations ranged from .21 to .54 on the subtests and between .49 and .54 when correlating the total score on the Metropolitan and scores on the various Iowa subtests.

A study by Kingston (1962) suggested the conclusion that the subtests of the Metropolitan Readiness Test may have differential predictive validity. While first grade Metropolitan scores correlated significantly with school achievement in third and fourth grade as measured by the Stanford Achievement Tests, the subtests with the highest predictive value were the Matching and Numbers subtests.

Kermoian (1962) reported that the total score on the Metropolitan had a correlation coefficient of .77 with teacher ratings of pupil readiness.

Others have reported results showing that the predictive value of the Metropolitan is not as good as one might conclude from the foregoing studies. Karlin (1957) found the correlation between the Metropolitan and the Gates (1942) Primary Reading Test to be .36, but this fell to .25 when the contributions of age and intelligence were partialed out. Bremer (1959) reported a relationship of only .40 ($p < .01$) between the Metropolitan total score and the Gray-Votew-Rogers General Achievement Tests; this means that errors in the prediction of scores on reading achievement tests were reduced for this sample by only 16% when made on the basis of the reading readiness test scores.

De Hirsch et al. (1966) have developed a test battery aimed at discovering whether a distinct pattern of perceptuomotor and oral language difficulties are predictive of difficulties with visual language as the child continues through school. The tests in de Hirsch's battery have been designed to identify such "high-risk" children at the kindergarten level. The theoretical position which underlay the construction of the tests held that difficulty with reading is related to lags in neurophysiological maturation. Consequently, the assumption was made that performance on these tests would reflect the child's maturational status and thus, if development is a consistent process, would be predictive of later functioning.

De Hirsch's research identified ten tests as being those which, in combination, would most effectively identify high-risk children. The test battery consisted of the following: Pencil Mastery task, which tested the subject's ability to grasp and control a pencil during graphomotor activities; Wepman's (1958) Auditory Discrimination Test in which 20 alternate word-pairs were presented and the subject was asked to judge whether they sounded the "same" or "different"; Three Bears task in which the number of words used by the child during his telling the story of "The Three Bears" was totaled; Categories test, which required that the subject produce generic names for three clusters of words; that part of the Horst Reversals Test which requires the subject to match two- and three-letter sequences; and an abbreviated version of the Gates (1942) Word Matching Test. Three of the remaining tests were interrelated: these were Word Recognition I, Word Recognition II, and Reproduction of Words Previously Taught. At the beginning of the session, the child was shown how to read two words, "boy" and "train," and was also told to copy them from a model. At the end of the session, the subject was required to select those words when they were exposed with others (Word Recognition II), to select them from among a group of words presented successively (Word Recognition I), and to write from memory as much of the two words as he was able to remember (Word Reproduction). The Bender-Gestalt Test (1938) was also administered to the subjects, although only six of the nine designs were used. The latter test was included because much time is spent in kindergarten helping children to recognize and to reproduce various forms and shapes. Such training should serve to familiarize kindergartners with visuomotor experiences, and the Bender evaluates the evolving competence in this area. Other investigators have found the Bender-Gestalt Test to be related to reading. Smith and Keogh (1962) reported correlation coefficients of .51 and .39 (both significant at the .01 level) between the Bender-Gestalt and the

Lee-Clark Reading Achievement Test, respectively. Koppitz, Mardis, and Stevens (1961) reported correlations ranging from .41 to .73 between the Bender-Gestalt and the Metropolitan Readiness Test and from .29 to .71 between the Bender-Gestalt and the Metropolitan Achievement Test. The same study reported correlations ranging from .63 to .66 between the Metropolitan Readiness and Achievement tests.

A problem that exists with the foregoing tests is that none of them is totally objective or nonverbal. The scores can be influenced by sex. Prescott (1955) reported that when beginning first grade boys and girls are matched according to chronological age, the Metropolitan Readiness Test performance of the girls is somewhat superior to that of the boys, the difference in mean score being 2.6 in favor of the girls ($p < .05$). Intelligence is another factor that complicates the interpretation of the readiness scores with the readiness tests often being confounded with intelligence. Bagford (1968) reported correlation coefficients of .31 to .50 between the subtests of the Metropolitan and verbal test scores on the Lorge-Thorndike Intelligence Test. In the aforementioned work by Karlin (1957), the relation between the Metropolitan Readiness and the Gates Primary Reading tests fell from .36 to .25 when the influence of age and intelligence was removed from the scores.

The Orienting Response

The orienting response (OR) was first described by Pavlov (1927). He referred to it as the "investigatory," "what-is-it," "orientation," or "adjusting" reflex. Attention was first drawn to this phenomenon in Pavlov's conditioning experiments with dogs. It was observed that the performance of a conditioned reflex was disrupted by any unusual stimulus occurring during the course of the experiment. This disruption of conditioning was indicated by motor behaviors on the part of the experimental animals which seemed to indicate that the dogs were "paying attention" to the novel stimulus (O'Connor, 1966).

Pavlov called this reaction an "investigatory reflex" and described its functioning as follows: ". . . It is this reflex which brings about the immediate response in man and animals to the slightest changes in the world around them, so that they immediately orientate their appropriate receptor organ in accordance with the perceptible quality in the agent bringing about the change, making full investigation of it. The biological significance of this reflex is obvious. If the animal were not provided with such a reflex its life would hang at every moment by a thread. In man this reflex has been greatly developed with far-reaching results, being represented in its highest form by inquisitiveness . . ." (Pavlov, 1927, p. 12).

Pavlov noted that even the most insignificant changes in environment--the softest sound, the faintest odor, the minutest change in the intensity of illumination--will call forth this reflex, and he felt that the investigatory reflex can be used to determine the degree to which the nervous system of a given animal is capable of discriminating between various stimuli.

The main function of the investigatory response thus seems to be the orienting of the organism's attention to whatever has changed in the environment so that he can prepare to respond. As Pavlov pointed out, the ability to do this can be a life-or-death matter. Berlyne (1960) has emphasized that immobility can be one of the gravest threats to an animal's survival. He goes on to suggest that this is especially important where urgent biological needs or imminent dangers have generated severe conflicts, as it is vital that the animal not react to such conflicts with paralysis, but rather actively work to overcome them.

The investigatory, or orientation, reflex allows the animal to act by mobilizing the skeletal musculature. Berlyne (1960) has pointed out that any activity that is already under way is stopped, so that it will not interfere with any measures of overriding priority that may be called for in order to deal with the danger. Motor resources are suspended pending the intake of enough information to select the most efficient course of action. Lynn (1966) has added other mobilizing functions to this list. He has reported that the sense organs become more sensitive and that the head is often turned toward the source of stimulation in order to maximize incoming information. The autonomic components of the reaction likewise prepare the body for emergency action.

When the orienting response is elicited, the responses that follow may be presumed to optimize the reception of the stimulus. Study of the orienting reponse in newborns helps to suggest this (Jeffrey, 1968). In the newborn infant, the OR habituates slowly and the attention of the infant tends to be dominated by those few stimuli that are most salient. Eventually with continued exposure, with development of the child, or with both, the OR will habituate to those cues which were initially most salient and allow less salient cues to elicit attending responses. Thus, as O'Connor (1966) has pointed out, the function of the responses that make up the OR appears to be, in the main, that of improving the perceptual capacities of the organism and its ability to process incoming information.

Sokolov has called the OR "the first response of the body to any type of stimulus. It tunes the corresponding analyzer to ensure optimal conditions for perception of the stimulus" (1963, p. 11). The OR involves muscular activity resulting in specific movements of eyes, lids, head, and trunk which consist of turning movements and of sniffing movements. There are secretory components of the OR, as well as autonomic reactions. A more complete list of components of the OR includes (Berlyne, 1960; Lynn, 1966):

1. Increase in sensitivity of the sense organs
    a. The pupil of the eye dilates;
    b. Photochemical changes, lowering the absolute threshold for intensity of light, occur in the retina;
    c. The auditory threshold is lowered.
2. Changes in the skeletal muscles that direct the sense organs
    a. The eyes open wide and turn toward a source of visual stimulation;
    b. The head turns toward a source of sound;
    c. Animals prick up their ears;
    d. Sniffing occurs.

3. Changes in general skeletal musculature

   a. Ongoing actions are temporarily arrested;

   b. General muscle tonus rises, increasing readiness for activity in the skeletal muscles;

   c. There may be diffuse bodily movements and vocalizations;

   d. There is an increase in muscular electrical activity that is detectable with an electromyograph.

4. Changes in the central nervous system

   a. Alpha waves, when present, disappear and give place to faster, more irregular EEG activity;

   b. When slower EEG waves, representative of a drowsy and somnolent state, are present, they are replaced by alpha waves;

   c. If, however, fast waves in the beta (14 to 30 cps) or gamma (over 30 cps) range are already present, an EEG change will not be an OR component.

5. Vegetative changes

   a. Vasoconstriction occurs in the limbs, while vasodilation occurs in the head;

   b. The galvanic skin response (GSR), an increase in the electrical conductance of the palm and the sole, occurs;

   c. Respiration rates: there is a delay, followed by increase in amplitude and decrease in frequency;

   d. Heart rates: in human Ss the heart rate slows.

Although these are the component responses which can occur with an OR, all of the components do not necessarily occur in all Ss. There are individual differences in which combinations occur and in the strength of the reactions (Lynn, 1966). Operationally, a component response of the OR may be defined as "any response which is elicited by the first presentation of the stimulus, and which, with repeated presentation of the stimulus, ceases to be elicited by it" (O'Connor, 1966, p. 12).

Sokolov (1963) distinguished between two varieties of the OR, the generalized and the localized. The generalized OR is elicited first and is characterized by higher frequency EEG rhythms over the whole of the cerebral cortex, an increase in arousal which can last for some time, and a tendency to habituate quickly, usually after 10 to 15 trials. When further repetitions of the stimulus have habituated the generalized OR, the localized one remains. This differs from the first in that the EEG desynchronization is confined to the cortical area of the particular sensory modality, the reaction subsides quickly, and is more resistant to habituation as it can survive for over 30 trials.

Sokolov (1963) has defined the OR as having three main properties: (a) nonspecificity with regard to the quality of the stimulus, (b) nonspecificity with regard to the intensity of the stimulus, and (c) selectivity of extinction of various properties of the stimulus with repeated presentation. Razran (1961) has defined and elaborated on the properties of the OR in different terms. He calls the main properties of the OR: (a) reactional primacy and holistic specificity, since the OR is the organism's normal reaction to a novel stimulus and this reaction is not a single reflex but a centrally organized, holistic system of distinguishable reactions; (b) extinguishability and transformability, because repeated presentations of some stimuli extinguish the OR while repeated presentations other stimuli transform the OR into another type of reaction; and (c) conditionability and reinforceability.

What determines whether an OR is evoked? Berlyne (1960) has listed the following as determinants of the OR: intensity, color, indicating stimuli (ORs can become attached to signals through learning), novelty, surprisingness, complexity, uncertainty, incongruity, and conflict. Berlyne states that ". . . the chances of a particular stimulus pattern in the contest for control over behavior depend, among other properties, on how novel the pattern is, to what extent it arouses or relieves uncertainty, to what extent it arouses or relieves conflict, and how complex it is" (p. 18).

Berlyne has offered two explanations for the phenomenon of a novel stimulus eliciting the OR. The first hypothesis suggests that novel stimuli owe their collective properties to the fact that they have not yet had a chance to lose effects that all stimuli originally possess. The second hypothesis suggests that novel stimuli are alike in inducing conflict. An interesting property of novel stimuli is that their effects, including their ability to influence stimulus selection, are not at their strongest with maximum novelty; an intermediate degree of novelty, where the stimulus resembles something that is well known, but is yet dissimilar enough to arouse interest, has the strongest effects. The degree of novelty of a stimulus will be inversely related to: (a) how often patterns that are similar enough to be relevant have been experienced before, (b) how recently they have been experienced, and (c) how similar they have been. The properties of change, surprisingness, and incongruity supplement that of novelty (Berlyne, 1960).

The degree of conflict engendered by stimuli seems to increase with: (a) the nearness to equality in strength of the competing response tendencies, (b) the absolute strength of the competing response tendencies, and (c) the number of competing response tendencies. An experiment reported by Berlyne (1961) has also shown that the intensity of the OR will increase with the degree of conflict.

Berlyne defines "complexity" as being the amount of variety or diversity in a stimulus pattern. The properties on which the degree of complexity ascribed to a pattern will depend are: (a) the number of distinguishable elements (complexity rises with an increasing number of elements), (b) complexity increases with dissimilarity between elements, and (c) complexity varies inversely with the degree to which several elements are responded to as a unit. Berlyne's experiments (1958) have shown that subjects spend more time looking at more complex and less familiar figures.

What happens to the OR if the stimulus that is presented is no longer novel to the S, or if any of the other factors that aid the elicitation of the OR are removed? When a stimulus is presented repeatedly the OR gets progressively weaker and eventually disappears. This phenomenon is known as habituation. Lynn (1966) has summarized the variables known to influence the process of habituation:

1. Stimulus variables:

   a. Intensity--Habituation rates are generally more rapid with low-intensity stimuli. An exception to this general statement lies in the phenomena of threshold stimuli; these stimuli are highly resistant to habituation.

b. Duration of stimuli--A very short stimulus either produces no reaction or the reaction is quickly habituated. Very lengthy stimulus presentations also lead to rapid habituation.

c. Difficult discrimination between stimuli--These conditions postpone habituation.

d. Temporal intervals--The shorter the intervals between stimuli, the quicker the habituation.

e. Spontaneous recovery--After the elapse of time following habituation, the OR shows some partial recovery. This eventually lessens and complete habituation occurs.

f. Disinhabituation--After a stimulus has been habituated, a strong extraneous stimulus restores the OR.

g. Generalization--A certain amount of generalization of the OR can occur.

h. Conditioned (signal) stimuli--If the stimuli have significance for the subject, habituation can be greatly prolonged.

2. Subject variables:

a. Cortical injury and ablation.

b. Phylogenetic differences.

c. Individual differences.

d. Drug effects.

An experiment by Leavy and Geer (1967) has reported evidence in conflict with Lynn's statement that medium-intensity stimuli are most resistant to habituation. These authors measured galvanic skin responses (GSR) to tones of 20, 30, 40, or 50 decibels (db) and found that OR resistance to habituation was a direct function of stimulus intensity. Uno and Grings (1965) used tone intensities of 60, 70, 80, 90, and 100 db and reported that response magnitudes and latencies were directly related to stimulus intensity and inversely related to the number of repetitions of the tone.

The OR is an extremely specific reaction. If the ORs to a particular stimulus are habituated by repeated presentation of this stimulus, then almost any change in the stimulus is sufficient to reinvoke an OR. Some degree of generalization of the OR to stimuli that are qualitatively or quantitatively similar can be observed, but extent of such generalization is small (O'Connor, 1966). Changes in the quality of the stimulus are not the only changes that bring about dehabituation; changes in stimulus intensity, in stimulus duration, in stimulus patterning, or in the temporal regularity of the presentation of the stimulus can have the same effect.

The process of dehabituation also occurs, or habituation may simply not come about, if the stimulus is given signal value. One way to accomplish this is to present the stimulus shortly before a biologically important event, such as shock (Notterman, 1953). The examiner can impose, through verbal instruction, a task requiring the subject to note the presence of the stimulus and its properties (Berlyne, 1960). If a stimulus is conditioned in this way, its OR becomes stronger and of shorter latency to the same stimulus than to a neutral stimulus. The OR will also occur to a wider range of stimuli at both ends of the intensity scale. Habituated ORs reactivated, and habituation of new ORs to the stimulus, occur very slowly.

Two kinds of neurological models have been proposed to explain how the habituation process occurs: one-stage and two-stage models (Lynn, 1966). One-stage models are those that assume that when a particular body of neurones is continually stimulated, an inhibitory process is generated in these neurones which raises their threshold of response and eventually eliminates the response entirely. The generation of inhibition is responsible for the diminuation and habituation of the OR.

Two-stage models embody one stage in which there is an analyzing mechanism to determine whether the stimulus is novel and significant and thus calls for an OR, and then a second stage in which excitatory or inhibitory mechanisms are set to work to evoke or suppress the OR. Sokolov has proposed a two-stage model where the analyzing stage is mediated cortically.

Sokolov (1963) has mentioned two reactions, other than the OR, that can be made to stimuli-adaptive and defensive reflexes. Adaptive reflexes bring about adaptation of the analyzer to the quality and intensity of the stimulus. These reactions act in the opposite direction to the OR, since they tend either to lessen the impact of a change in stimuli or to restore excitation to some optimal level (Berlyne, 1960). Adaptive responses are localized phenomena, being confined to those sense organs and parts of the central nervous system concerned with the particular modality to which the stimulus belongs. The adaptive reaction does not habituate rapidly.

Typically, an OR is the first reaction to a stimulus. After a number of trials, the OR can be replaced by the aforementioned adaptive reaction in the case of weak or moderate stimuli. If the stimulus is intense, a defensive reaction will occur. Defensive reactions resemble adaptive responses in that they behave so as to counteract stimulation, yet they share with the OR a generalized and pervasive character. A startle-defensive reaction has different components than the OR. The defense reaction produces a turning away from the source of stimulation, vasoconstriction in both head and limbs, a pause in respiration, increased heart rate, and a very slow rate of habituation.

It would appear from work by Dykman (Dykman, Reese, Galbrecht, & Thomasson, 1959) that background conditions apart from stimulus intensity are of importance in determining whether a subject will startle or orient. The Ss in their study who were drowsing at the time of the first presentation of a tone were more likely to startle than were the subjects who were awake.

Great disagreement has been evident in the psychological literature over the issue of whether the heart rate component of the OR is solely a decelerative one or whether it is a diphasic reaction, with the deceleration preceded by an initial acceleration. Graham and Clifton (1966) have reviewed the research done in this field and have suggested that those experiments obtaining heart rate deceleration were found to satisfy criteria identifying an OR and that instances of heart rate acceleration probably reflected a defensive or startle reaction. They found reason to suspect that the studies reporting a diphasic response to auditory stimuli used stimulus intensities strong enough to evoke a defense response either initially or within a few trials. Studies using auditory stimulation that was not as intense did not report cardiac acceleration.

An experiment by Chase and Graham (1967) has given support to this view. The heart rate response to the onset of 18-sec. nonsignal tones heard over 71 db white noise was found to be solely decelerative. This suggested to the authors that relative stimulus intensity is as important as absolute level in determining the form of the cardiac response.

Lacey, Kagan, Lacey, and Moss (1963) have found another reason for supporting the position that cardiac deceleration is a component of the OR. They found that deceleration occurred when the subject was required to attend to visual or auditory inputs, while acceleration resulted when the subject was solving mental arithmetic problems or was being painfully stimulated using the cold pressor procedure. They argue that cardiac deceleration accompanies "environmental intake," whereas acceleration accompanies "rejection of the environment." They also have reported evidence to support the view that pleasant stimuli produce deceleration while unpleasant stimuli produce acceleration. Lacey et al. have proposed that increased heart rate leads, via the carotid sinus and aortic baroreceptors, to inhibition of cortical activity and a reduction in sensitivity to stimulation. This would facilitate the "rejection of the environment" which they feel occurs when cardiac acceleration is present.

Experiments conducted by Lacey (1959) and Lacey et al. (1963) have supported this view. It was found that situations which required mental problem-solving activity produced an accelerative reaction whereas situations which demanded continual attentiveness to external stimuli produced deceleration. Other experimenters have produced similar findings. Kagan and Rosman (1964) required first and second grade boys to either attend to an external stimulus or elaborate mentally upon a stimulus. The attention episodes were accompanied by a decrease in cardiac rate. Obrist (1963) also found that sensory stimuli involving continuous environmental input lead to heart rate deceleration. Lewis, Kagan, Campbell, and Kalafat (1965) used 24-week-old infants to demonstrate that cardiac deceleration accompanies attention, as well as to demonstrate that the length of time the child fixates on the array is directly related to the degree of deceleration. Kagan and Lewis (1965) also tested children's reactions to pictures of faces and designs, patterns of blinking lights, and auditory stimuli. They found that the degree of deceleration was greatest for those stimuli that had greater fixation and lower movement scores. It was additionally found that among girls the high-attentive Ss showed greater cardiac deceleration.

Other investigators have reported the cardiac component of the OR as being a diphasic response, with deceleration following initial acceleration. Davis, Buchwald, and Frankmann (1955), Geer (1964), and Lang and Hnatiow (1962) have all reported this diphasic effect.

Research with exceptional children has shown how significant the OR may be for learning. To form a new connection between information and response it is essential to discriminate the given stimuli from a quantity of other stimuli. Only then does it become a conditioned signal, capable of evoking an adequate response reaction (Luria, 1963). If no preliminary discrimination of the stimuli occurs, a conditioned reflex to it cannot be formed. Luria has suggested that defects in attention that are seen in the mentally retarded child can be explained by a defect in the OR of the retarded child. Experiments in which vascular and galvanic skin responses of mentally retarded children were recorded showed that in a significant number of cases stimuli of a low or medium intensity which always evoke an OR in normal children did not evoke one in retarded children. The ORs of retarded children, when they do occur, are distinguishable from normal

ORs by their considerably lower resistance to extinction. The OR of the retardate also has special characteristics when verbal instructions are the relevant stimuli. The normal child's directedness of attention insures that other, irrelevant stimuli will not evoke ORs. The retarded child will usually not evidence a firm OR to the relevant stimuli and nothing will prevent a switch of attention to all kinds of incidental stimuli.

Zaporozhets (1961) has suggested that it is the haphazard and poorly directed ORs of young children that account for their difficulty in learning skilled movements. He reports several experiments in which children have been taught skills more successfully when their ORs (i.e., attention) have been directed to the components that are involved in the skill.

The OR has another important role to play in facilitating learning in that the elaboration of conditioned reflexes is facilitated by the prior occurrence of an OR (Sokolov, 1963). Establishment of a conditioned reflex is accompanied by eventual habituation of the OR. Preliminary habituation of the OR to the conditioned stimulus can serve to retard subsequent conditioning.

Maltzman (1967) has proceeded from the research outlined above to suggest that if individual differences (IDs) in the OR were stable across different situations, the result would be stable differences in many learning and perceptual tasks. If the OR corresponds to what is commonly thought of as "attention," such effects could be expected, provided that individual differences in the OR are not entirely specific to the stimulus conditions operating at the moment. Maltzman and Raskin (1965) have reported experiments investigating individual differences in the OR which have shown that IDs in the OR are related to the amount of semantic conditioning of autonomic responses, "awareness" or the ability to verbalize experimental contingencies, paired-associate learning in males, and differential responsiveness to signals.

This present study was undertaken in an attempt to see if the orienting response, a nonverbal set of bodily changes which occur as a response to stimulus change, could be used as a predictor of success in learning to read.

If the orienting response were found to be able to predict reading success, it could serve as a nonverbal, objective, and basic predictor of reading abilities and, as such, could serve as a valuable tool in aiding in the early diagnosis of children who are potential reading problems. It is hoped that the research could reveal information about the role of attention and discriminative ability in relation to learning and reading skills.

A sizable battery of instruments now exists that aims at predicting the degree to which a child possesses the reading readiness skills that will enable him to learn to read successfully and without undue effort, but none of these instruments has the capability of the OR of being measured at a preverbal, and therefore very young age level. The OR has been measured in infants as young as five days old (Graham, Clifton, & Hatton, 1968). Existing reading readiness tests show high correlations with instruments that purport to measure intelligence, experiential background, and areas of school skills. The use of the OR might provide a measure that was not confounded with these other factors and would therefore be more objective.

The main hypothesis of this study is that a fundamental aspect of the skills needed for success in learning to read is discriminative ability. Discriminative ability is indicated by sensitivity to differences among stimuli and environmental events. The OR will be used as an objective measure of such discriminative ability, and this study will measure differences between children in the magnitude of the OR as an indication of their discriminative ability. Changes in heart rate to the presentation of tones will be employed as the measure of the OR.

Individual differences in the magnitude of the OR will be compared to performance on the de Hirsch et al. (1966) reading readiness materials and to scores on the Metropolitan Readiness Test in order to determine if the orienting response can predict performance on these tests.

II

METHOD

Subjects

The sample consisted of 114 kindergarten children (age range 63-82 months) drawn from five kindergarten classes in a public elementary school located in Madison, Wisconsin (population approximately 170,000). All children in these classes were included in the study except those absent during testing days. Readable heart rate records were obtained for 123 children (five records were rejected as unreadable) with the final sample consisting of 114, as reading readiness measures were not available for nine of the Ss.

Apparatus and Materials

Heart rate was measured with a Gilson Model M5P polygraph, using cariotachometer channel five, and three plate electrodes with the ground electrode on the lower inner leg and the two remaining electrodes being attached one to each inner forearm. No skin preparation was employed, as ighly readable records were obtained without it. The pure tones were generated by a Beltone Model audiometer and delivered via an Electro-Voice Sonocaster loudspeaker of 8 ohms impedance.

The 1965 Metropolitan Reading Readiness tests (Hildreth et al., 1965) were used as well as the complete de Hirsch et al. (1966) test battery.

Procedure

The Ss were tested in an inner, 10' x 8', school psychologist's testing room on the second floor of the school, this room being separated from a general hallway by a second large room. Both rooms were sound-insulated. The testing room was illuminated by a 60-watt incandescent bulb located in a 5-foot lamp stand having a white paper barrel-shade. The Gilson polygraph, the Beltone audiometer, and a speaker connected to a white noise generator that was located in the outer portion of the testing room were placed in the testing room.

The S sat in a comfortable armchair, which was placed upon several layers of rubber padding in order to prevent any electrical contacts while the child was attached to the polygraph. A folding screen was placed between the chair and the wall that it faced in order to further increase the insulation and to decrease the possibility of a S coming into contact with the wall. A large pillow was placed between the S and one arm of the chair in order to decrease the S's movements and to make him more comfortable.

The noise levels in the room were determined by the use of a Stoelting noise level meter. The meter was used on Weighting A with the "slow" meter being employed. The noise level in the testing room was 58 db when the white noise generator and the polygraph were turned on. When, in addition to these, the audiometer delivered a 1000 cps tone, the noise level was measured at 61 db when taken vertically in front of S, 65 db when taken at the left ear, and 66 db when taken at the right ear. A 2000-cps tone raised the level to 70 db when taken vertically, 70 db at the left ear, and 71 db at the right ear.

The actual testing was conducted in the following manner. The examiner (E) obtained S from his kindergarten room and brought him upstairs to the testing room. The S then was seated in the armchair. As E attached the electrodes to the S's limbs, some instructions were given. The instructions were found to be necessary in order to prevent S from becoming anxious. It was noted that sitting alone in a darkened room without any knowledge of what would be happening was an extremely threatening experience to the five-year-old subjects. The instructions were as follows:

"Today I would like you to help me. Your job is very easy. All I would like you to do is sit very quietly in this chair and listen to some sounds that my machine will make. Do you think you can do that? Good. I know that you can. I'm going to put these three little plates on both arms and on one of your legs. Do they feel comfortable? Fine. Now I will go over to my machine and turn off one of the lights. I will always be in the room with you, but you will not be able to see me because

I will be standing behind your chair. Your job is just to sit quietly and listen. Are you ready? Let's start now."

If the S displayed any anxiety while the electrodes were being attached or if he asked questions about being hurt by the machine, he was assured that he would not be hurt and that he would not feel anything at all. If it were felt that the S needed further reassurance, the E would attach the electrodes to herself and turn the polygraph on so the S could see that nothing of a painful nature happened. A floor lamp was left on during the testing, both to provide a source of light and to decrease any fears which the S might have.

The E then turned on the polygraph and, for 3 min., the S heard white noise. After the 3-min. period had elapsed, the E delivered a 1000-cps tone by depressing a lever on the Beltone audiometer. The tone lasted for 5 sec. The choice of tones and intervals was determined both by an examination of the previous literature and by the results of a short pilot testing of several Ss. Fifteen 1000-cps tones were delivered at 15-sec. intervals. A sixteenth 5-sec. tone of 2000 cps was then delivered. Fifteen sec. after the delivery of that tone, the lamp was switched off. After 5 sec. the lamp was put on again, the electrodes were removed, and the S was told he could return to class.

The E tried to keep her movements as few and as quiet as possible in order that her movements should not become a signal to the Ss that something was about to happen. There was no communication between the E and the S during the testing, unless the E observed that the S was moving around excessively. If this were noted, the E would ask the S to sit as still as he possibly could.

III

RESULTS

The polygraph records for each S were scored in the following manner. The 3-sec. pre-stimulus period and the 3-sec. post-stimulus period were used to determine the magnitude of the OR for each S. Previous studies have used many different time intervals (or number of beats) for the pre-stimulus and post-stimulus periods. A 3-sec. interval was chosen on the basis of a pilot test. It was found that the S's heart beats on the whole were so cyclical that the use of a longer time period would confound the reading of the heart rate records with changes that were unrelated to the given stimulus. The single slowest heart beat was determined for each of these two periods and the difference between the two slowest beats was taken as representing the OR to the stimulus that had been presented. Graham and Clifton (1966) have cited previous studies where this method has been used.

Examination of the data revealed that the baseline heart rates of the Ss ranged from a score of 64 beats per minute to one of 123 beats per minute. This left a problem of trying to decide how a change of, for example, 10 beats per minute could be compared between Ss whose base rates might differ by almost 60 beats per minute. Wilder first formulated the problem. He offered the following definition of what he called the "Law of Initial Values" (1958):

> The change of any function of an organism due to a stimulus depends, to a large degree, on the pre-stimulus level of that function. That applies not only to the intensity (i.e., extent and duration) of response, but also to its direction. The higher this pre-stimulus level (the initial value), the smaller the tendency to rise on function-raising stimuli, the greater the tendency to drop on function-inhibiting stimuli. With more extreme high or low levels, there is a progressive tendency to "no response" or to "paradoxic reactions," i.e., to a reversal of the type of response: rise instead of fall, and vice versa. (P. 199)

In general then, the magnitude of the increase of changes decreases as the initial level increases. Before comparisons between different scores could be made, therefore, the change scores had to be freed from their correlations with their initial values, or baseline rates. This was achieved through an analysis of covariance.

The analysis of covariance took the observed change scores and filtered out the influence of the initial heart rate level. Thus, an adjusted change score (to be known as the residual score) was obtained for every S in the study. Similar analyses have been reported by Keen, Chase, and Graham (1965), and Graham, Clifton, and Hatton (1968) for heart rate.

The variables employed in the study, with their abbreviations as used in reporting the results, are as follows:

Sex--Identification as to whether S was male or female.

Group Code--All Ss were put into groups of either high, medium, or low "orienters" on the basis of their change in heart rate to the first stimulus (i.e., Trial 1 or first presentation of the 1000-cps tone) with the influence of initial or baseline heart rate removed (this criterion OR measure was termed "Residual 1": see below).

T1 Base--The baseline heart rate for Trial 1.

T1 Change--The difference between the slowest heart beat in the 3-sec. pre-stimulus period and the slowest beat in the 3-sec. post-stimulus period on Trial 1. This was here employed as an OR measure on the basis of Maltzman and Raskin's (1965) use of the OR (measured by GSR) to the first presentation of a stimulus in their analysis of the relationship between individual differences in the OR and conditioning.

T2 Base--The baseline heart rate for Trial 16.

T2 Change--The heart rate change on Trial 16 (2000-cps tone). This was included as a putative OR measure in that this trial represented a change in stimulation from the preceding 15 trials at 1000 cps each. The 1000-cps tone was administered for 15 trials (approximately 5 mins.) in order that the S would habituate to the 1000-cps tone to some degree, and thus the 2000-cps tone would represent a change from prevailing lack of stimulation. A pilot study indicated that the Ss became very restless if the testing continued beyond approximately 16 trials.

T3 Base--The baseline heart rate for Trial 17.

T3 Change--The heart rate change on Trial 17 (the light turned off). This was also included as a putative OR measure in that it also represented a change in stimulation.

Bender--The Bender-Gestalt Test (1938) of the de Hirsch test battery.

Gates--The Gates Word Matching (1942) subtest of the de Hirsch battery.

Pencil--Pencil usage test of the de Hirsch battery.

Auditory Discrimination X (ADX)--That part of the Wepman Test of the de Hirsch battery that required the S to judge if words sounded the same.

Auditory Discrimination Y (ADY)--That part of the Wepman Test of the de Hirsch battery that required the S to judge if words sounded "different."

Categories--Categories test of the de Hirsch battery.

Word Reversals (Reversals)--Reversals subtest of the de Hirsch battery.

Word Recognition I (WR I)--Word recognition test of the de Hirsch battery where the S picks out two words from a word deck.

Word Recognition II (WR II)--Word recognition test of the de Hirsch battery where the S picks out two words when they are included among other words.

Word Reproduction (Repro)--Reproduction subtest of the de Hirsch battery.

MR 1--The Word Meaning subtest of the Metropolitan Readiness Test.

MR 2--Listening subtest of the Metropolitan.

MR 3-- Matching subtest of the Metropolitan.

MR 4--Alphabet subtest of the Metropolitan.

MR 5--Numbers subtest of the Metropolitan.

MR 6--Copying subtest of the Metropolitan.

Residual 1 (Resid 1)--The heart rate score on the first trial after the influence of the baseline rate had been filtered out. This is simply T1 with the baseline contribution removed, and is the criterion OR measure in the present study.

Residual 2 (Resid 2)--The above procedure for Trial 16.

Residual 3 (Resid 3)--The above procedure for Trial 17.

Age--The S's age in months.

It should be noted that in all analyses applied to the data of female Ss, ADY was not included as a variate, due to these Ss demonstrating zero variance on this measure.

Discriminant Function Analysis

The main analysis used in this study was a discriminant function analysis. This analysis was performed on the data obtained from all Ss (N=114), from males (N=63) separately, and from females (N=51) separately. A discriminant function analysis was chosen in order that differences among groups might be identified. To look at it yet another way, the discriminant function analysis can be used to see if the criterion groups are different in terms of the other variables included in the study. In the present case, the discriminant function analysis was used to determine if the OR groups were differentiated by any of the readiness variables and, if so, which of these variables maximally discriminated among the groups. The variables in this study were interrelated and the discriminant function analysis can be used as a multivariate generalization of the t test in order to provide a single test of the null hypothesis that the means of the variables of all the OR groups concerned are identical (Snedecor & Cochran, 1967).

Maltzman and Raskin (1965) have provided a precedent for dividing the Ss into groups on the basis of the magnitude of their ORs. All Ss in the study were classified as either high, middle, or low orienters on the basis of their Trial 1 (initial onset of tone) residual scores, with the magnitude of heart rate deceleration indicating the magnitude of the OR (Graham & Clifton, 1966), such that the high OR group demonstrated the greatest deceleration and the low OR group the least deceleration with the middle OR group falling in between these two extremes. The discriminant function analysis was used to see if any of the reading readiness variables in the study would maximally discriminate among the three OR groups.

The mean scores for each OR group for all variables in the study are located in Tables 1-3. From these Tables, visual inspection of the means seems to suggest that, in most cases, the means are very similar for all three groups. In Tables 4-11 are presented the F ratios for the multivariate test of equality of mean vectors for all Ss, for males separately, and for females separately, both when comparing the high OR Ss to the low OR Ss and when comparing the middle group to an average of the high and low groups. Interest in the present context, of course, centers more on the former than on the latter analyses. From these tables it can be seen that the probability values obtained from the discriminant function analyses in no cases achieved significance, so that none of the readiness measures in the study could be said to maximally discriminate among the three OR groups.

The discriminant function analysis for male Ss (Table 9) and for the total sample (Table 5) looking at the middle group as compared to an average of the high group and the low group, did reveal that differences on the Bender-Gestalt test were significant ($p < .05$). This indicates that the middle Ss' performance on the Bender was significantly different from that of the averaged scores of the other groups. Inspection of the means reported in Tables 1 and 2 reveals that the middle group did better on the Bender than did the other two groups.

Table 1

Discriminant Function Analysis: Cell Means, All Subjects ($\underline{N}$=114)

Variable name & number		High OR	Medium OR	Low OR
1	Sex	1.400	1.436	1.514
2	T1 Base	86.400	89.564	94.943
3	T1 Change	-6.800	-3.205	1.114
4	T2 Base	85.175	89.333	96.171
5	T2 Change	0.250	-2.077	-2.886
6	T3 Base	85.875	89.795	97.171
7	T3 Change	0.500	-0.897	-0.800
8	Bender	1.175	0.667	1.171
9	Gates	3.425	2.897	3.114
10	Pencil	0.000	-0.026	-0.057
11	ADX	2.500	2.641	2.657
12	ADY	0.150	0.051	0.029
13	Categories	0.250	0.333	0.314
14	Reversals	1.950	1.974	1.314
15	WR I	0.350	0.282	0.257
16	WR II	0.500	0.410	0.457
17	Repro	3.550	3.769	3.914
18	MR 1	9.175	9.718	10.343
19	MR 2	10.125	9.923	10.400
20	MR 3	8.275	10.154	9.429
21	MR 4	9.800	10.641	10.914
22	MR 5	13.075	13.333	13.629
23	MR 6	7.250	7.436	8.400
24	Resid 1	-5.281	-0.302	6.371
25	Resid 2	-0.547	-0.876	1.601
26	Resid 3	-1.168	-0.899	2.337
27	Age	69.800	70.564	70.143

Table 2

Discriminant Function Analysis: Cell Means, Males (N=63)

Variables		High OR	Medium OR	Low OR
1	Bender	1.583	0.636	1.412
2	Gates	4.042	2.727	3.235
3	Pencil	-0.042	-0.045	0.000
4	ADX	2.833	2.409	2.941
5	ADY	0.208	0.091	0.059
6	Categories	0.375	0.318	0.353
7	Reversals	2.042	1.864	1.353
8	WR I	0.542	0.273	0.353
9	WR II	0.542	0.500	0.588
10	Repro	3.417	3.545	3.529
11	MR 1	9.417	10.045	10.941
12	MR 2	10.667	9.818	10.882
13	MR 3	8.250	11.500	9.176
14	MR 4	9.417	10.045	10.941
15	MR 5	13.625	13.955	14.294
16	MR 6	7.208	7.955	9.059

Table 3

Discriminant Function Analysis: Cell Means, Females (N=51)

Variables		High OR	Medium OR	Low OR
1	Bender	0.563	0.706	0.944
2	Gates	2.500	3.118	3.000
3	Pencil	0.063	0.000	-0.111
4	ADX	2.000	2.941	2.389
5	Categories	0.063	0.353	0.278
6	Reversals	1.813	2.118	1.278
7	Recog 1	0.063	0.294	0.167
8	Recog 2	0.438	0.294	0.333
9	Repro	3.750	4.059	4.278
10	MR 1	8.813	9.294	9.778
11	MR 2	9.313	10.059	9.944
12	MR 3	8.313	8.412	9.667
13	MR 4	10.375	11.412	10.889
14	MR 5	12.250	12.529	13.000
15	MR 6	7.313	6.765	7.778

Table 4

F Ratio for Multivariate Test of Equality of Mean Vectors = 0.764 for All Subjects (N=114): High vs. Low

df = 13 and 99 $p < 0.695$

Variable		Between Mean Sq	Univariate F	$p <$
1	Sex	0.240	0.954	0.331
2	Bender	0.013	0.010	0.922
3	Gates	2.008	0.225	0.636
4	Pencil	0.061	0.983	0.324
5	ADX	0.479	0.069	0.794
6	ADY	0.284	3.158	0.078
7	Categories	0.083	0.221	0.639
8	Reversals	7.118	1.898	0.171
9	WR I	0.165	0.512	0.476
10	WR II	0.040	0.104	0.748
11	Repro	2.504	1.639	0.203
12	Age	2.559	0.184	0.669

df for hypothesis = 1

df for error = 111

Table 5

F Ratio for Multivariate Test of Equality of Mean Vectors = 0.664 for All Subjects (N=114): High vs. Low

df = 6 and 106 $p < 0.679$

Variable		Between Mean Sq	Univariate F	$p <$
1	MR 1	25.416	2.996	0.086
2	MR 2	1.259	0.268	0.606
3	MR 3	27.514	0.447	0.505
4	MR 4	23.757	1.336	0.250
5	MR 5	5.712	0.284	0.595
6	MR 6	23.965	1.838	0.178

df for hypothesis = 1

df for error = 111

Table 6

F Ratio for Multivariate Test of Equality of Mean Vectors = 0.803 for All Subjects (N=114): Medium vs. Average of High and Low

df = 13 and 99 $p < 0.656$

Variable		Between Mean Sq	Univariate F	$p <$
1	Sex	0.012	0.046	0.831
2	Bender	6.574	4.695	0.032
3	Gates	3.549	0.398	0.529
4	Pencil	0.000	0.004	0.953
5	ADX	0.010	0.014	0.905
6	ADY	0.037	0.412	0.522
7	Categories	0.067	0.179	0.673
8	Reversals	3.000	0.792	0.375
9	WR I	0.012	0.037	0.848
10	WR II	0.120	0.315	0.576
11	Repro	0.035	0.023	0.880
12	Age	8.999	0.645	0.424

df for hypothesis = 1

df for error = 111

Table 7

F Ratio for Multivariate Test of Equality of Mean Vectors = 0.388 for All Subjects (N=114): Medium vs. Average of High and Low

df = 6 and 106 $p < 0.886$

Variable		Between Mean Sq	Univariate F	$p <$
1	MR 1	0.043	0.005	0.943
2	MR 2	2.952	0.629	0.430
3	MR 3	43.433	0.705	0.403
4	MR 4	2.065	0.116	0.734
5	MR 5	0.009	0.000	0.984
6	MR 6	3.879	0.297	0.587

df for hypothesis = 1

df for error = 111

Table 8

F Ratio for Multivariate Test of Equality of Mean Vectors = 0.619 for Males (N=51): High vs. Low

df = 16 and 45 $p < 0.852$

Variable		Between Mean Sq	Univariate F	p <
1	Bender	0.767	0.484	0.489
2	Gates	8.458	1.117	0.295
3	Pencil	0.015	0.472	0.495
4	ADX	0.025	0.003	0.958
5	ADY	0.241	1.656	0.203
6	Categories	0.008	0.016	0.899
7	Reversals	4.494	1.352	0.250
8	WR I	0.443	1.099	0.299
9	WR II	0.015	0.033	0.857
10	Repro	0.149	0.088	0.768
11	MR 1	22.876	2.672	0.107
12	MR 2	0.100	0.020	0.888
13	MR 3	16.096	0.153	0.697
14	MR 4	22.876	1.224	0.273
15	MR 5	4.494	0.202	0.655
16	MR 6	33.628	2.363	0.130

df for hypothesis = 1 df for error = 60

Table 9

F Ratio for Multivariate Test of Equality of Mean Vectors = 0.922 for Males (N=51): Medium vs. Average of High and Low

df = 16 and 45 $p < 0.551$

Variable		Between Mean Sq	Univariate F	p <
1	Bender	10.508	6.634	0.013
2	Gates	11.764	1.554	0.218
3	Pencil	0.009	0.269	0.606
4	ADX	3.240	0.373	0.544
5	ADY	0.026	0.178	0.675
6	Categories	0.030	0.063	0.803
7	Reversals	0.392	0.118	0.733
8	WR I	0.432	1.071	0.305
9	WR II	0.060	0.130	0.720
10	Repro	0.074	0.044	0.835
11	MR 1	0.252	0.030	0.864
12	MR 2	12.958	2.606	0.119
13	MR 3	10.037	1.046	0.311
14	MR 4	0.252	0.014	0.908
15	MR 5	0.000	0.000	0.997
16	MR 6	0.454	0.032	0.859

df for hypothesis = 1 df for error = 60

Table 10

F Ratio for Multivariate Test of Equality of Mean Vectors = 0.993 for Females (N=63): High vs. Low

df = 15 and 34 $p < 0.484$

Variable		Between Mean Sq	Univariate F	$p <$
1	Bender	1.249	1.239	0.271
2	Gates	1.999	0.189	0.666
3	Pencil	0.258	2.631	0.111
4	ADX	1.096	0.222	0.640
5	Categories	0.367	1.418	0.240
6	Reversals	2.633	0.575	0.452
7	WR I	0.080	0.428	0.516
8	WR II	0.086	0.306	0.590
9	Repro	2.346	1.891	0.176
10	MR 1	7.902	0.932	0.339
11	MR 2	3.208	0.780	0.382
12	MR 3	16.077	1.805	0.186
13	MR 4	1.980	0.115	0.736
14	MR 5	4.818	0.273	0.604
15	MR 6	2.086	0.178	0.676

df for hypothesis = 1 df for error = 48

Table 11

F Ratio for Multivariate Test of Equality of Mean Vectors = 0.428 for Females (N=63): Medium vs. Average of High and Low

df = 15 and 34 $p < 0.959$

Variable		Between Mean Sq	Univariate F	$p <$
1	Bender	0.026	0.025	0.874
2	Gates	1.530	0.144	0.706
3	Pencil	0.007	0.068	0.795
4	ADX	6.312	1.277	0.264
5	Categories	0.378	1.461	0.233
6	Reversals	3.710	0.810	0.373
7	WR I	0.365	1.953	0.169
8	WR II	0.094	0.336	0.565
9	Repro	0.023	0.018	0.893
10	MR 1	0.000	0.000	0.999
11	MR 2	2.096	0.510	0.479
12	MR 3	3.780	0.424	0.518
13	MR 4	6.884	0.400	0.530
14	MR 5	0.103	0.006	0.939
15	MR 6	6.895	0.585	0.448

df for hypothesis = 1 df for error = 48

However, given the number of variables involved in the total analysis, it is likely the present difference is due to chance. Additionally, the male data are likely accounting for the results obtained in the full sample analysis.

Principal Components Analysis

In order to examine the relationships among variables without being constrained by the tripartite division into high, middle, and low OR as was undertaken in the discriminant function analysis, and in order to describe the dimensionality of the data including the full range of scores in one analysis, a principal components analysis seemed appropriate. Such an analysis, employing the full range of scores, would be complementary to that of the discriminant function computation reported above.

All variables employed in the discriminant function analyses were intercorrelated by product-moment correlation, with this being done for the total sample, as found in Table 12, and separately for each sex, with the results for males shown in Table 13, and for females in Table 14. From Table 12, it can be seen that on the total sample the following readiness measures correlated significantly ($p < .05$) with one or more of the OR measures (these latter measures being the T1, T2, and T3 Change scores, as well as the Residual 1, Residual 2, and Residual 3 scores): Pencil, Bender, ADY, MR 1 (Word Meaning), and Word Recognition II.

Table 12

Correlation Matrix of Orienting Response and Reading Readiness Variables for All Subjects (N=114)

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1 Sex	1.000											
2 Group Code	.092	1.000										
3 T1 Change	.130	.270	1.000									
4 T2 Change	.113	-.103	.742	1.000								
5 T3 Change	.130	-.048	.744	.797	1.000							
6 Bender	-.192	-.009	-.127	**-.257	-.173	1.000						
7 Gates	-.081	-.045	-.045	.026	-.054	.257	1.000					
8 Pencil	.024	-.094	**.317	**.302	**.315	-.030	-.031	1.000				
9 ADX	-.050	.025	-.028	-.070	-.079	.317	.504	-.099	1.000			
10 ADY	-.178	-.166	*.203	**.356	*.257	.073	.234	.147	.121	1.000		
11 Categories	-.093	.045	-.034	-.077	-.027	.316	.397	-.065	.499	.160	1.000	
12 Reversals	-.017	-.129	-.050	.057	-.034	.170	.345	-.196	.382	.197	.328	1.000
13 WR I	-.195	-.068	-.044	-.012	.029	.197	.376	-.007	.317	.381	.254	.355
14 WR II	-.152	-.031	.066	.118	.165	.085	.323	-.037	.299	.187	.107	.254
15 Repro	.221	.121	-.059	-.177	-.194	-.084	-.253	-.081	-.275	-.300	-.224	-.313
16 MR 1	-.125	.162	-.127	-.204	*-.252	-.061	-.276	-.180	-.454	-.265	-.325	-.305
17 MR 2	-.149	.049	.074	-.006	.114	.079	-.222	.123	-.238	-.044	-.228	-.227
18 MR 3	-.052	.063	.032	-.024	.017	-.127	-.138	-.001	-.031	-.122	-.049	-.204
19 MR 4	.101	.109	-.055	-.042	-.152	-.183	-.419	-.023	-.454	-.355	-.292	-.326
20 MR 5	-.147	.051	.054	.004	.001	-.213	-.533	.137	-.538	-.217	-.435	-.425
21 MR 6	-.093	.127	.150	.099	.137	-.313	-.346	.158	-.391	-.179	-.288	-.439
22 Resid 1	*.212	**.480	**.827	**.603	**.624	**-.190	-.110	*.246	-.059	.047	-.055	-.027
23 Resid 2	.214	.083	**.534	**.814	**.619	*-.253	-.014	.183	-.103	.188	-.097	.079
24 Resid 3	.216	.150	**.550	**.597	**.823	*-.225	-.079	*.205	-.107	.090	-.025	-.010
25 Age	-.188	.041	.078	-.012	.028	-.030	.085	.091	.178	-.091	.134	.001

Table 12 (Continued)

Variable	13	14	15	16	17	18	19	20	21	22	23	24	25
1 Sex													
2 Group Code													
3 T1 Change													
4 T2 Change													
5 T3 Change													
6 Bender													
7 Gates													
8 Pencil													
9 ADX													
10 ADY													
11 Categories													
12 Reversals													
13 WR I	1.000												
14 WR II	.475	1.000											
15 Repro	-.395	-.285	1.000										
16 MR 1	-.212	-.234	.283	1.000									
17 MR 2	-.049	-.022	.194	.225	1.000								
18 MR 3	.008	.026	.109	.242	.182	1.000							
19 MR 4	-.417	-.469	.377	.566	.150	.033	1.000						
20 MR 5	-.291	-.287	.263	.450	.292	.001	.593	1.000					
21 MR 6	-.190	-.099	.266	.324	.252	.169	.294	.367	1.000				
22 Resid 1	-.108	.081	-.017	-.117	.068	-.015	.026	.085	.185	1.000			
23 Resid 2	-.108	.128	-.147	-.176	-.015	-.097	.047	.015	.079	**.707	1.000		
24 Resid 3	-.033	*.203	-.151	*-.243	.093	-.057	-.110	-.021	.134	.714	.752	1.000	
25 Age	.124	.048	-.083	-.001	.030	.024	.084	.141	-.004	.015	-.112	-.053	1.000

* $p < .05$

** $p < .01$

Table 13

Correlation Matrix of Orienting Response and Reading Readiness Variables for Males (N=63)

Variable		1	2	3	4	5	6	7	8	9	10	11	12
1	Group Code	1.000											
2	T1 Change	.646	1.000										
3	T2 Change	-.110	.016	1.000									
4	T3 Change	.020	.124	.123	1.000								
5	Bender	-.085	.029	-.162	-.065	1.000							
6	Gates	-.133	.012	.111	-.017	.277	1.000						
7	Pencil	.088	-.083	-.020	.069	.098	-.009	1.000					
8	ADX	.007	.107	.007	-.033	.354	.474	.013	1.000				
9	ADY	-.164	-.088	*.305	.046	.108	.369	.061	.193	1.000			
10	Categories	-.016	-.002	-.178	-.089	.373	.440	-.176	.577	.201	1.000		
11	Reversals	-.148	.115	.118	-.105	.195	.311	.030	.306	.319	.336	1.000	
12	WR I	-.133	.008	.034	.077	.191	.393	-.030	.228	.455	.198	.365	1.000
13	WR II	.023	-.015	-.057	.110	.073	.372	.011	.355	.170	.183	.200	.513
14	Repro	.038	.050	-.204	-.234	.025	-.179	.070	-.256	-.296	-.202	-.400	-.382
15	MR 1	.206	.100	-.129	-.154	-.208	-.345	-.090	-.580	-.322	-.422	-.348	-.321
16	MR 2	.018	-.039	-.030	.097	.013	-.366	.157	-.382	-.140	-.356	-.255	-.099
17	MR 3	.050	.051	-.054	.064	-.157	-.111	-.007	.018	-.150	-.014	-.203	.025
18	MR 4	.141	.051	.151	-.129	-.162	-.385	.002	-.520	-.428	-.272	-.315	-.520
19	MR 5	.058	-.059	-.039	-.006	-.318	-.581	.056	-.610	-.368	-.546	-.354	-.388
20	MR 6	.195	.055	-.294	-.059	-.344	-.470	.023	-.429	-.344	-.355	-.543	-.209
21	Resid 1	.710	.681	.048	.130	-.102	- 064	.141	.054	-.204	-.093	.066	-.073
22	Resid 2	.163	.037	.758	.189	-.198	.000	.137	-.036	.076	-.225	.029	-.082
23	Resid 3	.256	.062	.102	.743	-.210	-.053	.197	-.062	-.101	-.141	-.135	-.033
24	Age	-.084	.009	-.074	-.068	-.044	.143	-.064	.094	-.213	.059	.070	-.102

Table 13 (Continued)

Variable	13	14	15	16	17	18	19	20	21	22	23	24
1 Group Code												
2 T1 Change												
3 T2 Change												
4 T3 Change												
5 Bender												
6 Gates												
7 Pencil												
8 ADX												
9 ADY												
10 Categories												
11 Reversals												
12 WR I												
13 WR II	1.000											
14 Repro	-.315	1.000										
15 MR 1	-.415	.362	1.000									
16 MR 2	-.114	.307	.329	1.000								
17 MR 3	.063	.130	.214	.198	1.000							
18 MR 4	-.571	.415	.520	.232	-.063	1.000						
19 MR 5	-.386	.270	.490	.372	-.090	.635	1.000					
20 MR 6	-.082	.436	.455	.376	.139	.333	.499	1.000				
21 Resid 1	.092	-.020	-.028	.019	-.051	.105	.096	.102	1.000			
22 Resid 2	.070	-.211	-.141	.043	-.136	.192	.111	-.153	.491	1.000		
23 Resid 3	.208	-.206	-.177	.108	-.065	-.064	.090	.036	.525	.539	1.000	
24 Age	.021	.060	.017	.053	.024	.143	.112	.003	.041	-.069	-.059	1.000

*$p < .05$

Table 14

Correlation Matrix of Orienting Response
and Reading Readiness Variables for Females (N=51)

Variable - Name & Number	1	2	3	4	5	6	7	8	9	10	11	12
1 Group Code	1.000											
2 T1 Change	.102	1.000										
3 T2 Change	-.132	.890	1.000									
4 T3 Change	-.108	.900	.929	1.000								
5 Bender	.159	-.225	**-.361	-.253	1.000							
6 Gates	.062	-.058	.006	-.059	.216	1.000						
7 Pencil	-.228	**.435	.397	**.386	-.143	-.042	1.000					
8 ADX	.067	-.114	-.130	-.120	.226	.569	-.216	1.000				
9 Categories	.167	-.043	-.011	.028	.159	.345	.029	.327	1.000			
10 Reversals	-.108	-.124	.039	-.004	.146	.377	-.336	.507	.335	1.000		
11 WR I	.092	-.046	-.004	.062	.106	.361	.026	.520	.349	.379	1.000	
12 WR II	-.079	.178	*.300	*.291	.023	.252	-.078	.171	-.092	.341	.337	1.000
13 Repro	.195	-.191	-.252	*-.278	-.171	-.324	-.226	-.300	-.227	-.224	-.346	-.162
14 MR 1	.138	-.239	-.254	*-.319	.112	-.230	-.257	-.280	-.213	-.270	-.109	-.009
15 MR 2	.126	.189	.039	.184	.122	-.088	.119	-.009	-.047	-.210	-.047	.074
16 MR 3	.190	.081	.016	-.003	-.096	-.369	.017	-.329	-.298	-.379	-.176	-.215
17 MR 4	.049	-.144	-.176	-.215	-.178	-.452	-.048	-.342	-.313	-.342	-.204	-.283
18 MR 5	.075	.165	.059	.040	-.122	-.530	.224	-.449	-.295	-.534	-.251	-.194
19 MR 6	.060	.257	**.362	*.295	-.332	-.227	.286	-.346	-.201	-.333	-.226	-.173
20 Resid 1	.285	.907	.813	.807	-.234	-.121	*.299	-.172	.025	-.091	-.076	.158
21 Resid 2	-.017	.719	.866	.784	*-.271	.006	.206	-.173	.081	.126	-.063	*.291
22 Resid 3	.036	.724	.780	.879	-.192	-.072	.210	-.151	.145	.087	.064	*.309
23 Age	.212	.158	.048	.112	-.107	.004	.200	.293	.212	-.071	.405	.019

Table 14 (Continued)

Variable - Name & Number	13	14	15	16	17	18	19	20	21	22	23
1 Group Code											
2 T1 Change											
3 T2 Change											
4 T3 Change											
5 Bender											
6 Gates											
7 Pencil											
8 ADX											
9 Categories											
10 Reversals											
11 WR I											
12 WR II											
13 Repro	1.000										
14 MR 1	.264	1.000									
15 MR 2	.120	.043	1.000								
16 MR 3	.158	.489	.173	1.000							
17 MR 4	.291	.674	.075	.512	1.000						
18 MR 5	.365	.369	.127	.385	.594	1.000					
19 MR 6	.071	.121	.036	.378	.266	.140	1.000				
20 Resid 1	-.108	-.154	.190	.128	-.086	.151	*.325	1.000			
21 Resid 2	-.208	-.170	-.007	-.033	-.127	-.013	**.358	.818	1.000		
22 Resid 3	-.225	*-.272	.157	-.044	-.207	-.064	*.284	.804	.861	1.000	
23 Age	-.173	-.071	-.060	-.009	.064	.125	-.054	.070	-.080	.021	1.000

*p < .05

*p < .01

For the male Ss, as summarized in Table 13, only ADY attained significance ($p \leq .05$). The following were significantly correlated ($p < .05$) with at least one of the OR measures for females, as summarized in Table 14: Pencil, MR 6 (Copying), Word Recognition II, Reproduction, MR 1 (Word Meaning), and Bender. It is interesting to note that only one readiness variable showed any correlation with the OR among males, whereas 18 readiness variables were related to those measures for females.

Additionally, it might be noted that comparison of Tables 13 and 14 reveals a marked moderating effect of sex on the relationships among the OR variables. These variables demonstrate exceedingly few significant relationships in the males (three significant correlations, $p < .01$), whereas with the females, all 12 correlations are significant ($p < .01$). Where the relationships among the de Hirsch measures are concerned, 32% of the correlations (25 out of 78) were significant ($p < .05$) for females, whereas 24% (23 out of 94) were significant for males, again suggesting a (slight) moderating effect of sex on the consistency of individual differences across the tests. With the Metropolitan Tests, 47% of the correlations (7 out of 15) were significant ($p < .05$) for females, whereas 60% (9 out of 15) were significant ($p < .05$) for males, suggesting an inversion of the results obtained with the de Hirsch and OR data.

Where the principal components analysis itself is concerned, its use lies largely in ". . . arriving at a reduced number of abstract variables and a weighting of observed variables according to structural indications in the data itself" (Cattell, 1966, p. 174). It can be a useful aid in indicating which factors may be accounting for the variance in the data, as well as which of the variables seem to fall together.

The correlation matrix was subjected to a principal components analysis, followed by analytical factor rotations. The number of factors retained was determined by the eigenvalue > 1.00 criterion. Having set the number of factors to be extracted, factor loadings were computed by the principal components method and the normal varimax (Kaiser, 1958) procedure for analytic rotation to orthogonal simple structure was applied to the principal component solution.

Results of the principal components analysis (that is, the varimax loadings) for all Ss, and separately by sex, are presented in Tables 15-17. Loadings equal to or greater than .30 have been considered significant and have been underlined in each factor matrix. Seven factors were extracted for the whole group and for females separately, while eight factors were extracted for males.

The analysis involving all Ss is reported in Table 15. Factor One (accounting for 19.7% of the total variance) had loading of over .30 for T1, T2, and T3 Change, Pencil, and Residual 1, Residual 2, and Residual 3. This would appear to be an OR component. Factor Two (accounting for 15.8% of the total variance) had significant loadings for Bender, Gates, ADX, Categories, Reversals, WR I, MR 1, 2, 4, 5, and 6. This component seems to be a combination of the de Hirsch and Metropolitan batteries. Factor Three (9.3%) seems to be predominantly a de Hirsch factor, with Sex, ADY, Reversals, WR I and II, Repro, and MR 4 loading on it. Factor Four (6.1%) would appear to be an OR-influenced component with Group Code, Residual 1 (upon which Group Code is based), Pencil, MR 1, and ADY appearing together.

Factor Five (6.0%) might be a perceptually oriented factor. Reversals, MR 2 (Listening), MR 3 (Matching), and MR 6 (Copying) fall together on this factor. Factor Six (accounting for 5.3% of the total variance) appears to be a highly specific one with only Sex and Age loading on it, with the latter clearly defining the factor. Factor Seven (5.1%) is composed of Bender, MR 2 (Listening), and Sex, seeming to be highly specific to the first two variables.

The results for male Ss only are reported in Table 16. From this table it can be seen that Factor One (accounting for 16.9% of the total variance) is a de Hirsch-Metropolitan factor with Bender, Gates, ADX, Categories, Reversals, and MR 1, 2, 4, 5, and 6 loading on it. Factor

Table 15

Incomplete Principal Components Analysis--
Rotated Factor Matrix--All Subjects (N=114)

Variable - Name & Number		1	2	3	4	5	6	7
1	Sex	225	-194	-564	053	028	331	-342
2	Group Code	222	-042	-171	774	128	104	185
3	T1 Change	858	-022	-045	062	071	138	147
4	T2 Change	851	059	124	-239	-089	-001	-112
5	T3 Change	874	-004	103	-213	088	003	019
6	Bender	-239	-348	061	090	-263	-051	693
7	Gates	-054	-619	292	022	-134	061	031
8	Pencil	358	-018	-189	-563	166	258	297
9	ADX	-080	-784	151	097	-026	194	021
10	ADY	239	-156	458	-366	-224	-140	205
11	Categories	-053	-654	055	098	-144	239	136
12	Reversals	-008	-422	374	118	-450	-088	-184
13	WR I	-052	-321	699	-025	035	059	077
14	WR II	146	-285	664	096	214	-099	-066
15	Repro	-148	254	-552	170	235	-159	113
16	MR 1	-251	666	-009	367	099	045	091
17	MR 2	072	361	070	005	307	-077	581
18	MR 3	-062	043	065	083	764	009	-042
19	MR 4	-069	658	-404	201	-147	220	-043
20	MR 5	026	793	-153	-008	-039	288	119
21	MR 6	161	514	-069	023	463	087	034
22	Resid 1	883	011	-111	316	035	060	057
23	Resid 2	837	087	046	025	-176	-133	-186
24	Resid 3	849	-003	044	042	050	-116	-085
25	Age	-010	-052	087	027	057	879	-071

Note: Decimal points omitted.

Table 16

Incomplete Principal Components Analysis--
Rotated Factor Matrix--Males (N=63)

	Variable - Name & Number	1	2	3	4	5	6	7	8
1	Group Code	-068	-087	882	084	-069	060	011	-089
2	T1 Change	061	015	872	-092	012	052	-064	-037
3	T2 Change	022	-006	-055	018	951	019	-061	-077
4	T3 Change	000	073	-001	804	070	081	021	-117
5	Bender	529	-032	-030	-199	-204	-138	505	-123
6	Gates	633	334	-044	-111	154	-008	035	150
7	Pencil	-038	029	032	158	057	-089	760	-032
8	ADX	822	180	092	043	-031	047	010	104
9	ADY	221	503	-174	-158	325	-125	076	-410
10	Categories	763	040	004	-081	-212	-047	-135	021
11	Reversals	349	424	066	-256	180	-466	-009	099
12	WR I	141	836	-035	-085	008	-019	036	-100
13	WR II	211	727	064	245	-088	100	019	203
14	Repro	-200	-481	037	-279	-199	352	336	071
15	MR 1	-603	-313	137	-316	-085	258	-055	-029
16	MR 2	-501	-009	-038	015	006	315	525	092
17	MR 3	-009	068	027	-008	-010	870	-064	031
18	MR 4	-435	-691	099	-175	193	-052	044	172
19	MR 5	-766	-361	-004	035	-009	-161	059	182
20	MR 6	-656	-114	144	032	-358	279	040	079
21	Resid 1	-048	-010	875	276	161	-114	099	158
22	Resid 2	-076	-051	210	360	824	-115	082	066
23	Resid 3	-092	041	226	906	158	-063	105	052
24	Age	058	-043	-042	-096	-010	006	-022	908

Note: Decimal points omitted.

Table 17

Incomplete Principal Components Analysis--Rotated Factor Matrix--Females (N=51)

Variable - Name & Number		1	2	3	4	5	6	7
1	Group Code	066	022	156	168	-087	845	195
2	T1 Change	907	-102	-061	136	-088	-018	151
3	T2 Change	942	005	-035	029	023	-185	-101
4	T3 Change	940	-008	-099	086	015	-161	065
5	Bender	-305	413	025	-118	053	110	611
6	Gates	-056	703	-237	069	136	041	059
7	Pencil	349	-066	-101	290	-539	-497	179
8	ADX	-177	557	-266	394	273	139	042
9	Categories	032	498	-291	256	-178	370	-059
10	Reversals	-003	513	-269	-031	543	097	-262
11	WR I	-009	464	-008	646	314	-011	005
12	WR II	297	133	-035	092	774	-207	137
13	Repro	-221	-682	-000	-211	089	400	-041
14	MR 1	-237	-168	818	-062	170	104	069
15	MR 2	154	-165	037	-016	009	065	767
16	MR 3	066	-188	756	-035	-214	077	100
17	MR 4	-162	-427	730	094	-072	011	-102
18	MR 5	049	-709	348	216	-152	-030	153
19	MR 6	404	-051	442	-182	-443	-039	-238
20	Resid 1	926	-092	023	026	-068	214	092
21	Resid 2	909	080	018	-152	084	016	-165
22	Resid 3	907	063	-076	-044	083	055	007
23	Age	048	-027	-005	891	-089	097	-079

Note: Decimal points omitted.

Two (accounting for 11.6% of the total variance) is a de Hirsch factor, being composed of Gates, Reversals, ADY, WR I and II, Repro, and MR 1, 4, and 5. Factor Three (10.5%) is an OR factor specific to Trial 1, loading Group Code, T1 Change, and Residual 1 together. Factor Four (9.0%) is a similar OR factor, largely specific to Trial 17 (i.e., T3 and Resid 3), involving T3 Change, MR 1 (Word Meaning), and Residual 2 and 3. Factor Five (9.8%) is an OR factor largely specific to Trial 16 (i.e., T2 and Resid 2). It is composed of T2 Change, ADY, MR 6 (Copying), and Residual 2.

Factor Six (accounting for 6.1% of the total variance) seems to be involved with discriminative ability in that Reversals, Repro, and MR 2 (Listening) and MR 3 (Matching) load on it. It is interesting that the OR does not load on this factor. Factor Seven (5.4%) seems to be a perceptual-motor ability factor, consisting of Bender, Repro, Pencil, and MR 2 (Listening). Factor Eight (5.2%) seems clearly to be a factor specific to Age, with a moderate loading of ADY.

The results for the female Ss only are reported in Table 17, where it can be seen that the first factor (accounting for 25.1% of the total variance) is an OR factor with T1, T2, and T3 Change, and all three residual scores loading on it, and with low to moderate loadings for Bender, Pencil, and MR 6 (Copying). Factor Two (13.0%) is a de Hirsch factor with significant loadings for Bender, Gates, ADX, Categories, Reversals, WR I, Repro, and MR 4 (Alphabet) and MR 5 (Numbers). MR 1, MR 3, MR 4, MR 5, and MR 6 loaded on Factor Three (10.6%) making this clearly a Metropolitan factor. WR I, ADX, and Age loaded on Factor Four (7.7%) with Age primarily defining this factor.

Discriminative ability may account for the loadings on Factor Five (7.7%), which were Pencil, Reversals, WR I, WR II, and MR 6 (Copying). Factors Six (6.5%) and Seven (5.7%) appear to be rather specific ones, with Group Code, Pencil, Categories, and Repro appearing on Factor Six, with Group Code defining the factor, and significant Bender and MR 2 (Listening) loadings appearing on Factor Seven.

Reliability of the OR Measures

As the OR measures have been used in the present study in a relatively unique fashion as individual difference variables, it seemed useful to estimate their stability. This was undertaken by retesting 25 of the Ss (15 male, 10 female) under conditions that approximated those of the original testing as closely as possible. A retest interval of exactly 7 days was used with all Ss being retested at the same time of day, and by the same E as on original testing. No S was forewarned that he would be retested. Product-moment correlations between first and second testing for each of the three baseline measures, three change scores, and three residual scores were calculated, and are contained in Table 18. From Table 18 it can be seen that only the adjusted or residual scores based on T2 Change (2000-cps tone following 15 tones at 1000 cps) and T3 Change (Light out) demonstrate significant ($p < .01$) reliability estimates.

Table 18

Test-Retest Reliability Correlation Matrix

Variable-name & number	1	2	3	4	5	6	7	8	9	10	11	12
1 T1 Base	1.000	-.798	.955	-.761	.959	-.775	-.139	.414	.112	.268	.069	.214
2 T1 Change		1.000	-.803	.940	-.817	.947	.520	-.163	.226	.109	-.138	.210
3 T2 Base			1.000	-.808	.966	-.817	-.052	.443	.139	.232	.130	.153
4 T2 Change				1.000	-.821	.968	.328	-.067	.252	.099	-.178	.216
5 T3 Base					1.000	-.337	-.099	.383	.056	.247	.057	.147
6 T3 Change						1.000	.286	-.220	.314	.146	-.198	.257
7 Resid 1							1.000	.393	.408	.086	.117	.168
8 Resid 2								1.000	.431	-.072	.134	-.024
9 Resid 3									1.000	.190	-.045	.304
10 T1 Base Retest										1.000	-.312	.869
11 T1 Change Retest											1.000	-.290
12 T2 Base Retest												1.000
13 T2 Change Retest												
14 T3 Base Retest												
15 T3 Change Retest												
16 Resid 1 Retest												
17 Resid 2 Retest												
18 Resid 3 Retest												

Variable - name & number	13	14	15	16	17	18
1 T1 Base	.068	.166	.255	.166	.115	.303
2 T1 Change	.123	.234	-.109	-.108	.169	-.052
3 T2 Base	.117	.081	.244	.217	.150	.270
4 T2 Change	.056	.200	-.095	-.152	.104	-.047
5 T3 Base	.076	.099	.235	.146	.108	.266
6 T3 Change	-.027	.240	-.026	-.157	.032	.034
7 Resid 1	.589	.201	.035	.153	.616	.087
8 Resid 2	.490	-.020	.169	.116	**.475	.168
9 Resid 3	.218	.175	.487	.019	.283	**.543
10 T1 Base Retest	-.111	.758	.141	.022	.089	.337
11 T1 Change Retest	.129	-.155	-.184	.943	.060	-.228
12 T2 Base Retest	-.036	.795	.170	-.001	.192	.375
13 T2 Change Retest	1.000	.056	.081	.097	.974	.097
14 T3 Base Retest		1.000	-.220	.102	.235	.029
15 T3 Change Retest			1.000	-.145	.118	.969
16 Resid 1 Retest				1.000	.095	-.122
17 Resid 2 Retest					1.000	.181
18 Resid 3 Retest						1.000

**p < .01

DISCUSSION AND CONCLUSION

In arriving at conclusions about this study, it would seem relatively incontrovertible that using the present experimental procedures and methods of data analysis, individual differences in the OR have demonstrated rather slight contributions to performance on the various readiness measures. This conclusion is particularly clear where the performance of males is concerned. However, where the females are concerned, there is slightly more reason for encouragement. Four of the 15 readiness measures loaded significantly on the OR factor. These measures all seem to require the subject to make either visual or auditory discriminations between words, figures, or subunits of a figure. However, other tests or subtests which would also seem to require discriminations did not load significantly on the OR factor. That inconsistent contributions of any discriminative ability were appearing on the various readiness tests themselves is suggested by the relatively low degree of relationships among these measures. No strong factor appeared in either sex that contained significant loadings of all or even a major portion of the readiness measures. For the males, one factor contained significant loadings for ten of these measures, while the comparable factor for the females contained nine significant loadings.

No obvious reason suggests itself to account for the differences in pervasiveness of contribution of the OR to test performance between the males and females. Perhaps there are test reliability differences at this age between males and females, with this difference influencing the correlations of OR and readiness measures. Another factor is the use of a female experimenter in obtaining the OR measures for all subjects. This might have led to variance differences in the OR measure between males and females that might have influenced the OR correlations with the readiness tests; however, no such differences were detected.

The lack of pervasive contribution of the OR to the other tasks may lie in the relatively loose test administration procedures for at least the Metropolitan, that is, the large-group test administration by a teacher. The tests should be administered under conditions hopefully as well controlled as those of the OR measurement.

Another problem may lie in the grossness of the measures represented in the readiness tasks. A more satisfactory strategy than the present one would be to perform the analyses at the item level rather than using subtest total scores each based on a number of items that may not all reflect identical psychological processes. By working at the item level, an item analysis could be performed against the OR score, and the items bearing significant relationships could be examined for common properties.

The present research is being extended to the use of individual items administered individually to subjects under controlled conditions. In addition, the school achievement of the present subjects is being followed up.

Although further refinement is needed, as noted above, this study is of considerable use in providing a methodology for future research. As mentioned at the outset, the potential power of such an approach lies in the development of basic nonverbal predictors of reading readiness and/or reading failure. Additionally, the approach may be useful in adding such an individual differences term to experimental studies of component skills in prereading.

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Appendix

Residual Scores for High, Middle, and Low OR Groups

High OR group

Residual 1	Residual 2	Residual 3
-29.30	-1.55	- 2.16
-14.24	+ .32	+ 8.73
-10.86	+2.54	+ 9.81
-10.17	-8.55	+ .57
- 9.86	+7.06	-11.58
- 8.73	+ .52	-11.20
- 8.20	+1.90	+ 3.91
- 8.14	-19.38	-13.30
- 7.11	+2.54	- 7.08
- 6.96	+8.80	+ 3.15
- 6.33	-2.55	+ 1.61
- 6.05	+7.22	+ 1.88
- 5.80	-3.46	- 2.54
- 5.71	-4.65	- 1.73
- 5.67	+6.26	- 3.12
- 5.61	-3.55	- 1.35
- 5.33	+1.68	+ 5.95
- 5.17	-4.33	- 9.50
- 5.02	-2.55	- 7.04
- 4.96	+3.67	- 4.73
- 4.58	-8.04	- 1.97
- 4.43	+ .54	- 2.66
- 4.43	-5.33	+ 6.04
- 4.26	-5.27	- 7.09
- 4.24	-1.04	- 2.16
- 4.21	- .55	- 7.39
- 4.20	+10.47	+ 3.11
- 4.11	+5.29	- 1.28
- 4.05	+11.38	+ 5.89
- 3.86	-2.78	+ 4.07
- 3.73	+2.87	-11.24
- 3.52	+2.39	- .89
- 3.39	-4.17	+ 2.81
- 2.74	+4.02	- 1.19
- 2.58	-8.42	- 1.66
- 2.57	+2.16	+ .22
- 2.45	-1.65	- 7.66
- 2.38	-19.74	- 8.74

Middle OR group

Residual 1	Residual 2	Residual 3
-2.36	+4.96	-2.81
-2.33	-7.46	-13.19
-2.17	-3.10	-2.74
-1.83	+2.35	-3.58
-1.79	+6.55	+7.72
-1.77	-6.94	- .93
-1.67	-15.65	-9.27
-1.58	-3.98	+1.23
-1.52	+10.74	-3.43
-1.43	+4.02	-3.85
-1.27	+2.28	-7.43
-1.21	-1.75	+4.23
- .98	+1.00	+6.11
- .83	-1.04	-2.16
- .83	-1.06	+ .84
- .71	+14.06	-2.73
- .68	-7.46	-9.19
- .58	-6.46	-3.73
- .45	-1.48	-2.89
- .33	+9.06	+5.73
- .21	-3.46	-1.62
- .14	+ .71	-7.47
- .02	- .26	- .35
+ .17	+ .87	+4.34
+ .23	+2.35	-5.70
+ .42	-4.06	+ .91
+ .48	+2.74	+2.99
+ .51	-2.20	-9.19
+ .74	+10.55	+13.76
+ .80	+2.29	+1.03
+ .98	-1.52	+6.30
+ .98	+9.31	-3.62
+1.02	-12.61	+7.30
+1.05	+3.16	-3.14
+1.17	+2.35	+ .76
+1.23	- .39	-5.16
+1.36	+4.03	+10.68
+1.45	-1.87	-1.24

Low OR group

Residual 1	Residual 2	Residual 3
+1.45	+2.09	- .78
+1.58	+6.48	-4.63
+1.80	-1.36	+11.57
+1.85	-3.39	+2.76
+1.86	-10.39	+6.57
+1.95	+7.77	-8.43
+1.98	+1.32	- .73
+2.14	+1.45	-1.27
+2.33	+5.58	+3.42
+2.55	-1.13	-1.12
+2.64	-2.00	-3.09
+2.68	+7.45	+7.72
+2.79	+2.77	+8.57
+2.95	+4.03	- .63
+3.17	-2.65	-5.35
+3.20	-21.65	-2.62
+3.23	-15.65	-7.35
+3.45	-1.52	-1.24
+3.46	+9.45	+3.41
+3.80	+3.07	- .09
+4.14	-1.04	-1.70
+4.21	+2.84	+ .41
+4.45	-2.42	-2.81
+4.76	+1.29	+5.11
+5.20	+4.93	-5.04
+6.23	-1.97	- .32
+6.42	-14.26	+2.04
+6.80	+ .09	-1.93
+7.20	-5.20	-17.27
+7.24	+3.23	+8.72
+7.40	+8.20	+2.45
+7.92	-10.91	+3.65
+8.27	+9.83	+2.65
+8.49	+4.19	+4.03
+9.89	+2.58	+6.07
+12.27	+2.55	+ .49
+12.42	+ .54	+ .07
+16.42	+5.54	+10.27

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Descriptive Statistics

All Subjects

Variable Numbers		Means	Standard Deviations	Variances
1	Sex	1.447	.499	.249
2	Group Code	1.956	.813	.661
3	T1 Change	-3.140	11.900	141.610
4	T2 Change	-1.508	12.482	155.790
5	T3 Change	- .377	11.330	128.380
6	Bender	1.000	1.197	1.433
7	Gates	3.149	2.966	8.800
8	Pencil	.0263	.247	.061
9	ADX	2.596	2.612	6.826
10	ADY	.078	.301	.091
11	Categories	.298	.608	.370
12	Reversals	1.763	1.952	3.810
13	WR I	.298	.563	.317
14	WR II	.456	.611	.374
15	Repro	3.736	1.234	1.523
16	MR 1	9.719	2.925	8.557
17	MR 2	10.140	2.157	4.652
18	MR 3	9.271	7.817	61.120
19	MR 4	10.430	4.207	17.699
20	MR 5	13.333	4.451	19.817
21	MR 6	7.666	3.613	13.056
22	Resid 1	.000	9.844	96.908
23	Resid 2	.000	10.160	103.230
24	Resid 3	.000	9.325	86.968
25	Age	70.167	3.715	13.804

Descriptive Statistics

Males

Variable Numbers		Means	Standard Deviations	Variances
1	Group Code	1.888	.805	.648
2	T1 Change	-4.523	6.640	44.092
3	T2 Change	-2.777	6.971	48.595
4	T3 Change	-1.698	6.095	37.150
5	Bender	1.206	1.309	1.714
6	Gates	3.365	2.766	7.654
7	Pencil	.031	.176	.031
8	ADX	2.714	2.909	8.465
9	ADY	.126	.380	.144
10	Categories	.349	.675	.456
11	Reversals	1.793	1.815	3.295
12	WR I	.396	.636	.404
13	WR II	.539	.667	.445
14	Repro	3.492	1.281	1.641
15	MR 1	10.048	2.942	8.659
16	MR 2	10.429	2.241	5.023
17	MR 3	9.634	.101	103.880
18	MR 4	10.048	4.297	18.465
19	MR 5	13.921	4.646	21.590
20	MR 6	7.968	3.784	14.322
21	Resid 1	-1.867	7.966	63.472
22	Resid 2	-1.943	8.302	68.928
23	Resid 3	-1.808	7.451	55.530
24	Age	70.794	3.446	11.876

Descriptive Statistics

Females

Variable Numbers		Means	Standard Deviations	Variances
1	Group Code	2.039	.823	.678
2	T1 Change	-1.431	16.124	259.970
3	T2 Change	.058	16.950	287.300
4	T3 Change	1.254	15.465	239.150
5	Bender	.745	.996	.993
6	Gates	2.882	3.204	10.266
7	Pencil	-.019	.315	.099
8	ADX	2.451	2.211	4.892
9	Categories	.235	.513	.263
10	Reversals	1.725	2.126	4.523
11	WR I	.176	.433	.188
12	WR II	.352	.522	.272
13	Repro	4.039	1.112	1.238
14	MR 1	9.313	2.880	8.299
15	MR 2	9.784	2.013	4.052
16	MR 3	8.823	2.991	8.948
17	MR 4	10.902	4.085	16.690
18	MR 5	12.608	4.128	17.043
19	MR 6	7.294	3.390	11.492
20	Resid 1	2.306	11.423	130.490
21	Resid 2	2.400	11.713	137.190
22	Resid 3	2.233	10.885	118.480
23	Age	69.392	3.919	15.363

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