EXAMINATION OF INTRA VS. INTERSENSORY INTEGRATION ABILITIES IN NORMAL AND RETARDED READERS USING LINGUISTIC MATERIALS

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by

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ABSTRACT

The hypothesis under investigation poses that retarded readers, i.e., dyslexic children, would be characterized by deficits in their ability to integrate auditory and visual information when compared with normal readers. Twenty second and third grade retarded readers were compared with twenty adequate readers on four recognition tasks, requiring both intrasensory and intersensory processing of auditory and visual linguistic material. In the intersensory conditions, the subjects were presented with a three letter trigram in one mode and were required to recognize its equivalent from a set of four trigrams presented in the other mode, i.e., auditory to visual matching or visual to auditory matching. This condition required subjects to integrate auditory and visual information in order to make equivalence judgments across modalities. In the two intrasensory conditions all presentations were in the same mode, i.e., either auditory or visual. Fifteen trials in each condition were presented to all subjects.

The results demonstrated highly significant deficiencies in retarded readers' ability to make auditory to visual and visual to auditory recognition responses. These deficiencies correlated with reading scores and appeared to be independent

of (not significantly correlated with) IQ scores, rotational or sequential visual memory, auditory memory, or verbal coding abilities.

The results indicated two types of retarded readers: 1) those that had difficulty in intrasensory tasks and, therefore, were deficient in intersensory tasks and 2) those with adequate abilities in intrasensory processing but were deficient in only the task requiring integration of the two modalities. It was suggested that in future research it would be instructive to differentiate these two populations before experimentation, in order to minimize confounded results found in previous studies in the field.

This study represents extensive methodological improvements over previous research in the investigation of auditory-visual integration abilities in retarded readers. These improvements include - and are a result of criticisms concerning the lack of - controls over: 1) intrasensory processing; 2) temporal-spatial factors; 3) conceptual-mediational strategies; 4) verbal labeling abilities, and 5) the questionable relationship of previous AVI research to the reading process. Furthermore, the present study has supported the major contention of Birch and Belmont (1964) that, although not totally independent of perceptual processing (auditory and visual), inabilities in auditory-visual integration processing are a prevalent characteristic and probable causal factor in retarded readers.

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The research on dyslexia (a learning disability) is steadily growing and improving in this decade as the subject matter gains increasing applicability. It is my hope that the research conducted for this thesis will contribute to the quality of evidence that is emerging and will aid professionals and laypeople alike to comprehend the problems faced by retarded readers. Therefore, I wish to express my gratitude to everyone who helped to produce this thesis.

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INTRODUCTION

PURPOSE: CONCEPTUAL ISSUES AND RATIONALE FOR RESEARCH

Because of many conflicting definitions and criteria employed to differentiate the dyslexic from the normal child, researchers have generally identified dyslexic children by their major and common characteristic: difficulty with learning to read - hence, the label, retarded readers (RR). The criterion for inclusion in the RR group is lack of ability to read relative to one's expected level of proficiency in the absence of: primary emotional disturbances, general intellectual deficits, known environmental, social or educational deprivations, or explicitly demonstrable neurological impairments (thus differentiating the neurological, post-traumatic dyslexia from the educationally designated connotation). The child's reading scores are observed to be retarded by at least one year from what would be expected from chronological age. It should be noted that the terms RR and dyslexia are used interchangeably throughout this paper.

It is generally accepted that developmental or specific dyslexia implies two fundamental characteristics: one, that the reading difficulty is specific to the reading process and two, that it stems from anomalies of maturation or development which are primarily constitutionally determined. This general notion has been expressed specifically by Money (1967), Hartstein (1971), and Goldberg and Schiffman (1972).

Although the existence of specific reading disabilities is well established and accepted in the fields of education, psychology, and medicine (Naidoo, 1970), the causal factors have remained in a perplexing and controversial state. Four primary hypotheses are extant in the literature regarding etiology of the RR, although they are not mutually exclusive. The first is a genetic hypothesis based on frequency of occurrence among family members (McGlannon, 1968, Rutter, et al, 1970) and supporting evidence from three studies of monozygotic and dizygotic twins (Herman, 1959). A second proposal, originally stated by Orton (1937) is that of the unusually extended latency with which cerebral dominance is established between the two hemispheres in RR children (also supported by Ettlinger and Jackson; 1955, Zangwill, 1960; and Zurif and Carson, 1970). The third hypothesis is one of general developmental-neurological delays reflected by normal but slow maturation of the brain (Rutter, et al, 1970; Critchly, 1964; and Goodnow, 1971). Finally, the fourth hypothesis states that dyslexia stems from organic brain dysfunction, specifically related to predisposing factors in early prenatal conditions (Kinsbourne and Warrington, 1963; Boshes and Myklebust, 1964).

Concerns for identifying common characteristics of dyslexia appear to be widespread for several reasons. First, as Luria (1966) and Flax (1968) have emphasized, it is important to differentiate those disorders of the development of abilities from those of acquired inflictions associated with brain damage (commonly in the left hemisphere). The accepted implication is that for those with developmental dyslexia, once the psychological and educational component difficulties have been identified, intervention by established techniques generally proves most beneficial and successful; i.e., the child does acquire reading and writing skills (N.B. Ayres, 1972; Hurley, 1968). Thus, research on identification of specific deficits and implementation of appropriate remedial techniques is of concern and value.

Second, it has become apparent that a significant number of children are affected by such difficulties. Using intelligence and mental age criteria for expected level of reading achievement, MacMeeken (1939) found 9.1% of children between the ages of seven years, six months and ten years, six months had reading quotients of less than

85% of their intelligence quotients (IQ); that is to say, they were approximately eighteen to twenty-four months behind in expected reading abilities. Kellmer, Pringle, et al, (1966), in a United Kingdom national survey of 11,000 seven year olds, demonstrated that 11.2% of boys and 5.9% girls were significantly deficient in reading using similar criteria. Rutter, et al, (1970) studied 2,299 children between the ages of seven and twelve years and found 3.5% who were two or more years behind in reading skills (in the absence of any neurological deficits). Mackworth (1972) estimated eight million dyslexic children in the United States alone need treatment for difficulties in reading. Estimates range from roughly 3% to 15% depending on the criteria used (Clark, Ginsburg, et al, 1970, 1971). Clearly, there are a significant proportion of children needing specialized instruction in reading.

> "We know from two recent government surveys of Chalfant and Schellelin (1969) and by Templeton (1969) that these highly important practical problems facing so many children and their parents simply cannot be solved without more information about the cognitive processes involved in normal and abnormal reading, and without a better understanding of the nature of the difficulties." (Mackworth, 1972, p. 683).

Finally, beyond the awareness that so many children are involved and that dyslexia is a known, treatable problem, is the fact that reading is so important in our society that research on identification and treatment of children with reading deficits may be justified on humanistic grounds. Literacy is frequently used as an indication of one's mental capacity and often determines one's economic success and mobility. Furthermore, the adverse psychological consequences of being denied academic rewards and success is socially devastating. (See the Sunday Herald Advertiser, Boston, Massachusetts, November 9, 1975.)

It is, therefore, imperative to continue research in order to identify precisely what the deficiencies are and how they are manifested so that accurate and effective programs of remediation may be developed, supported, and employed to improve the deficient skills of these children to a level of competence equal to their capacity.

ANALYSIS OF THE READING PROCESS

In order to analyze and promote productive research on the component difficulties of the RR, one must analyze the normal reading processes, then identify deficiencies relative to that process. Once the spoken language has been well established, the task of reading involves interpreting or transforming (decoding) a complex array of abstract graphic symbols to a corresponding set of previously established spoken sounds. Conversely, writing (specifically spelling) involves a process by which spoken words must be systematically and accurately encoded in order to transform those identical sounds to graphic representations. This phoneme-grapheme transformation, which must occur mentally and efficiently, necessarily demands a process of visual (V) to auditory (A) and an A to V sensory integration. This process of integration between modalities is assumed to be a higher order cognitive process than the more basic A and V discrimination abilities within either sense modality. It has been consistently observed, both experimentally and clinically, that the primary and common identifying factor for RR is an apparent inability to decipher accurately the written word into spoken language and vice versa.

Gibson (1965) has stated in a widely recognized article on the development of reading skills that,

> "Once the child begins his progression from spoken language to written language, there are phases of learning to be considered: learning to differentiate graphic symbols; learning to decode letters to sounds [and encode sounds to letters] ; and learning to use progressively higher-order units of structure." (p. 292).

Gibson has therefore specified the prerequisite abilities required for the development of efficient reading. Cognitive research on dyslexic disturbances in the acquisition of reading skills has focused on these stages of development and will be discussed below in that order.

PERCEPTUAL DEFICITS HYPOTHESIS
(Review and Evaluation)

As in the first stage of Gibson's description of the reading process, many investigators hypothesized that perceptual discrimination deficits are the major source of difficulty for the RR. It was thought that if the child perceived linguistic information inaccurately then reading skills could not be developed adequately. Several early investigations set out to study V or A (intrasensory) acuity and perceptual difficulties. Fildes (1921), Monroe (1932), and Harrington and Russell (1955) found evidence that RR are inferior to normal readers (NR) in visual form perception, spatial orientation, and A and V discrimination tasks. Orton (1937) indicated that disorganization of spatial sequential abilities, V perception and V memory, were salient features of dyslexia. His main treatise involved impairment of directional abilities (spatial orientation) in perceiving symbolic stimuli (i.e., reading), while other visual functions were thought to be normal (i.e., recognition and interpretation of objects, persons, pictorial or diagrammatical materials).

There is, however, an abundance of research that fails to support a strictly A or V perceptual impairment hypothesis. Many researchers attempted to replicate earlier studies only to find that RR and NR do not differ in perceptual or discrimination abilities (Gates, 1922; Reilly, 1971).

Benton (1962) reviewed the major investigations in the literature up to that time and found major weaknesses in design and control factors. He concluded that deficient form perception is not an important correlate of reading retardation. He does suggest that perceptual difficulties may be found in RR at young ages, but that reading problems in older children are most likely due to other higher-order dysfunctioning.

It is apparent that the expected highly significant and direct relationship between auditory and visual discrimination and reading skill did not materialize, although in some situations, a relationship was found. Reilly (1971) states, having reviewed the literature, that:

> "The combination of various approaches to auditory [and visual, which were discussed earlier] discrimination and reading skills have resulted in equivocal results and uncertainty as to the nature of their relationship. Thus far, predictive studies have been unable to appreciably affect the variance already established by mental age, which itself can account for only less than half the variance." (p. 482).

One possible explanation for discrepancies in earlier research concerning the perceptual deficit hypothesis is that the use of linguistic stimuli appears to confound results. Goetzinger, et al, (1960) and Wepman (1970) suggested that by using linguistic material one is more apt to find a significant relationship between A and V perception and/or discrimination abilities and reading (independent of IQ); while, in contrast, employing non-linguistic stimuli results in insignificant relationships. Orton (1937) suggested that RR difficulties are specific to linguistic material. Intrasensory functioning will be discussed further in later sections, but it should be concluded that "pure" auditory or visual perceptual deficits (e.g., without the confounding of linguistic integration) have yielded equivocal results in RR children.

SENSORY INTEGRATION DEFICIT HYPOTHESIS
(Review and Evaluation)

Meaningful areas of study have been developed by investigating possible higher-order cognitive deficits as suggested by Gibson's second and third stages of learning to read. These involve sensory integration processes necessary to associate graphic symbols with their corresponding verbal or auditory equivalents.

> "More recent studies, concerned with auditory and visual discrimination and integration skills have tended to focus on intersensory systems and reading success. This appears to be a more profitable approach since a basic lack in the area of auditory and visual discrimination and integration skills has been

> [in] research combining the effects of both modalities and relating them to relevant areas of reading." (Reilly, 1971, pp. 482-483).

The first major experimentation and hypothesis concerning integration abilities in RR, and upon which most subsequent research - including this investigation - is based was developed by Birch and Belmont (1964). They stated that:

> "Learning to read as an educational task requires the ability to transform temporally distributed auditory patterns to spatially distributed visual ones....a primary disturbance in the ability to integrate stimuli from the two sense modalities, hearing and vision, may well serve to increase the risk of becoming a poor reader." (p. 858).

They set out to examine Auditory-Visual Integration (AVI) abilities and differences among NR and RR. Their rationale for such an investigation was straightforward: even though RR children, as a class, represent a heterogeneous group, the one common characteristic is an inability to read efficiently. Because learning to read is so heavily dependent on the ability to deal with information deriving from two sense modalities - that is, the ability to integrate or assimilate auditory and visual information effectively - it was hypothesized (in lieu of the fact that studies on purely perceptual difficulties produced equivocal results) that "among the possible causes for subnormalities in learning to read could be a primary inadequacy in the ability to integrade auditory and visual stimuli." (Birch and Belmont, 1964, p. 853).

To test the hypothesis that impairment of AVI would occur more commonly in a group of RR children than it would in an NR control group, Birch et al, (1964) developed an AVI recognition equivalence task (match-to-sample). They presented a group of one hundred and seventy-three RR and NR children between the ages of nine years, four months and ten years, four months (with normal IQ's) a series of ten auditory rhythmic patterns of pencil taps with short intervals of 0.5 seconds and long intervals of 1 second between taps. The subjects (Ss) were required to choose from among three patterns of typewritten dots the one that represented the visual equivalent of the auditory pattern. When two groups were then compared on their ability to make such AVI equivalence judgements, the results clearly demonstrated that the RR group had a significantly lower mean number of correct responses. Birch and Belmont concluded that poor readers dealt less effectively with a task requiring judgements of auditory and visual equivalents. Furthermore, it was found that the relationship between AVI abilities and reading in this task not only distinguished between groups but also tended to identify those Ss with the lower reading scores within each group. Although there was a significant difference between the groups' mean IQ, when the lower normal levels of IQ were eliminated, the effect was sustained but to a slightly lesser degree. It was found that IQ scores accounted for less than 15% of the total variance accounted for by the Birch and Belmont test. Thus, Birch et al, (1964) concluded that these results supported Rabinovitch's (1954) suggestion that difficulties in integration are the major problem faced by children with primary reading retardation.

Although this relationship between AVI and reading ability has been demonstrated consistently in all related research (Birch and Belmont, 1964-65; Muehl and Kremenak, 1966; Beery, 1967; Kahn and Birch, 1968; Reilly, 1972; Voort, Senf, and Benton, 1972; Bryden, 1972; Gregory and Gregory, 1963), there are some questions raised by Birch and Belmont's design and consequent interpretations. The first difficulties stem from lack of control over method of presentation, (i.e., use of pencil taps) and from IQ differences between RR and NR (Sterritt and Rudnick, 1966). But when these two factors are carefully controlled, the main effect is still maintained (Beery, 1967; Kahn and Birch, 1968).

Major methodological criticisms also have been asserted on the basis of experimental design and lack of controls. The most crucial criticisms arise from research which has investigated the lack of intramodal controls (Vande Voote, et al, 1972), abilities to equate temporal-sequential stimulation to spatially presented information (Bryden, 1972), conceptualization (Goodnow, 1971) or mediational factors particularly important for the ability to apply effective strategies in such tasks, i.e., verbal labeling abilities (MacKinnon, 1973), and finally, the relevance and applicability of such tasks to linguistic material (Barnsley, et al, 1973). Each of these criticism areas will be discussed in detail in the following sections for the purpose of illuminating possible confounding variables in AVI research, using the Birch and Belmont method of investigation. Finally, studies that indicate that the AVI hypothesis remains a viable causal factor in RR's difficulty in dealing efficiently with linguistic material will be reviewed. All these confounding variables in Birch and Belmont's research design will be controlled and accounted for in the present research design.

AVI METHODOLOGY: INTRASENSORY CONTROL FACTORS
(Review and Evaluation)

There is clearly a necessity for evaluating within modality performance to determine whether a possible disability in either the auditory or visual modes may have been responsible for the observed differences in AVI performance.

Muehl and Kremenak (1966) were the first to investigate intra versus intermodal processing using the Birch and Belmont method. One hundred nineteen Ss (ages six to seven years) were given tasks requiring auditory to auditory (AA), visual to visual (VV), auditory to visual (AV), and visual to auditory (VA) processing, where the stimuli and response sets were similar to those employed by Birch and Belmont (1964). The only procedural difference, besides the inclusion of an intramodal condition was that Ss were to make a "same - different" response to test stimuli. The results revealed that when IQ and age were controlled, there was a marked difference in the Ss' ability to make equivalence judgements between the dot-dash pattern depending on the mode(s) required. Over both groups, matching the VV pairs was the easiest; AA pairs, the most difficult; and AV or VA pairs were of intermediate difficulty (AV being somewhat more difficult than VA). Furthermore, the ability to match VA and AV pairs made significant contributions to predicting reading; thus, "the general ability to relate information from the auditory to the visual sense, with IQ controlled, was markedly associated with later reading achievement. Neither AA nor VV contributed independently to predicting reading achievement." (Muehl, et al, 1966, p. 235).

Vande Voote, et al, (1972) used a modified Birch and Belmont technique which included a greater number of more difficult VV items and a number of simpler AA items (Beery, 1967), to control for noted ceiling and floor effects. Subjects were between eight years and twelve years, eleven months, and all Ss had IQ scores above 90. Tasks involved AA, VV, and AV matches. Results illustrated a clearly greater deficit on cross-modal (AV) performance by RR when compared to VV tasks, but not when compared to the AA task. The AA matching difficulty could account for the AV deficiency, and an intersensory integration explanation was not necessary to explain deficits in AVI processing in RR children. Thus, the hypothesis that RR is related to a specific AVI deficit received equivocal support. Furthermore, a detailed analysis of results gave no support to the conclusion that memory factors could account for the results on inferior AVI performance (Clifton-Everest, 1974; Vellutino, et al, 1975); even when memory demands were greatly reduced (by AV-simultaneous), RR still performed more poorly than did controls (reader is referred to Vande Voote, 1972, p. 1269 - for detailed description and evidence against impairment of memory factors in related tasks).

Similar findings using paired associate tasks have been reported. Employing a non-verbal paired associate task (A and V), Vellutino, et al, (1973) studied the possible influence of intra-modal deficiencies in assessing inter-modal (AVI) functioning in RR and NR. Non-meaningful geometric shapes and non-sense sounds were used as stimuli. The groups did not differ significantly in any of the treatment conditions, and thus, they rejected the hypothesis that RR would show significant difficulty in intersensory learning. But again, A appeared to be the most difficult for both groups; V tasks were easiest; AV and VA were intermediate - indicating a similar trend toward previous findings (Muehl and Kremenak, 1966). They concluded that those RR who did not differ on intrasensory tasks did not differ on intersensory tasks. They did suggest, however, that the possibility remains "that poor readers sustain primary integrational difficulties unique to visual-verbal learning...and that the integration of linguistic and visual stimuli may be quite different from the auditory-visual integration of non-verbal stimuli." (p. 120). These results preclude any assurance that the higher incidence of AVI difficulties between RR and NR is independent of intrasensory deficiencies.

Zigmond (1966) employed both intra and intersensory

(A and V) tasks using meaningful paired associate trials. In Zigmond's study, RR were found to be inferior to NR on all nine measures of auditory functioning, six of seven intersensory tasks, and only one of four visual tasks. This data also indicated that auditory associations were the most difficult for both groups, while visual associations were the easiest to learn. Zigmond concluded that A deficiencies are more important in reading disabilities than either visual inadequacies or intersensory disorders. The author suggested, however, that her results may have been due to the unequal difficulty of the measure employed and cautioned against the dismissal of an intersensory explanation of reading disabilities (p. 94). Furthermore, the tasks employed had largely verbal components, thus (as previously mentioned) making it difficult to assess the degree to which apparent A perception difficulties were related to or dependent on the use of linguistic material.

On the basis of these studies of intersensory and intrasensory (perceptual and learning) functioning, one must conclude that for both groups VV is easiest, AA more difficult, cross modal intermediate. Significant differences between RR and NR have been demonstrated in the perceptual-intramodal processing of A information. This has generally not been true with V processing. RR do not differ appreciably in their ability to deal efficiently with V information. In all but one study (Vellutino, et al, 1973), VA and AV tasks do discriminate between the groups of RR and NR. In some of the aforementioned studies, this later finding (demonstration of AVI deficit) is attributed to deficiencies in A processing in RR and in others, auditory functioning appears independent of AVI deficiencies. Although these results do not unequivocally support an AVI deficit hypothesis (because of demonstrated A deficits in RR), researchers have located other unique differences between A and V stimuli presentations besides the mode of reception. These characteristics account for these findings - that of auditory deficiencies in RR. One possible reason for RR difficulty in dealing with auditory presentations is that A stimuli must be presented temporally, whereas visual material is presented spatially. Therefore, RR may not have difficulty in A perception but in the processing of temporally presented stimuli.

TEMPORAL-SPATIAL FACTORS IN AVI METHODOLOGY
(Review and Evaluation)

Blank and Bridger (1966) noted that in the Birch and Belmont tasks the stimuli and matching sets to be equated not only differed in the sense modality required to complete the task (A to V), but also differed along the spatio-temporal dimensions. The visual stimuli were always presented spatially, the auditory stimuli, temporally. It was pointed out that quite different perceptual and cognitive processes might be involved in dealing effectively with spatial vs. temporal stimuli. It is possible that RR have difficulty not in intermodal transfer or in auditory perception, but rather in establishing equivalence between temporal and spatial stimuli.

To test Blank and Bridger's hypothesis, Bryden (1972) compared RR and NR using combinations of three different presentation modes: auditory sequential patterns (A'); visual sequential patterns (V') - same as auditory using one-flashing light; and a visual spatial-dot pattern (D). All combinations were employed for all 107, sixth grade Ss (i.e., A'A', A'V', A'D, V'A', V'V', V'D, DA', DV'). On the basis of this study, Bryden concludes:

> "The poor readers were found to be inferior in matching an auditory sequence to a visual dot pattern...(and) also showed equivalent deficits on all other tasks involving matching one (sequential or temporal) pattern with another...Research has used different forms of temporal-spatial matching to find which aspects of these tasks are most closely correlated with reading. There is some evidence that matching temporal patterns within one modality is at least as strongly correlated with reading as cross-modal matching." (p. 831).

This difficulty in processing temporal information explains why A processing was found to be most difficult, VV easiest, and AV intermediate in previously examined sections. These results suggest that the difficulty in processing A stimuli (for RR) may be due to a deficit in processing temporal characteristics.

CONCEPTUAL-MEDIATIONAL DEFICITS IN AVI METHODOLOGY (Review and Evaluation)

Blank and Bridger (1966) having demonstrated that temporal aspects in presentation of information (particularly through A mode) might relate to discrepancies in RR and NR functioning (Birch and Belmont, 1966), began to question the process by which temporal information is mediated. They hypothesized that temporal presentations would be more difficult for RR than NR, but more importantly that this task must require the application of mediational procedures to code the stimulus events. The Birch and Belmont task does not represent a simple intersensory task, but one that requires complex conceptualization. It is therefore, necessary to determine the role of how the child conceptualizes the task and stimuli in matching equivalences and what mediational strategies may be involved. A series of experiments were designed to examine the role of stimulus characteristics and the verbal strategies employed by children to handle them.

To test this hypothesis, twenty-six NR and RR ranging in age from nine years, four months to nine years, eleven months (matched for IQ and vocabulary scores) were given a series of tasks to perform. The first task was intended to compare RR and NR on their ability to convert temporal stimuli to spatial stimuli within the same modality (vision). Lights were emitted from a single red pilot light which flashed a half second between short intervals and one second between long intervals. These light patterns were compared, by the S, to dot patterns that were similar to those used in the Birch and Belmont series. The results demonstrated that RRs were deficient in making temporal to spatial equivalence in intramodal transfer (significant beyond .005 level). This finding indicates that RR did not simply differ in intermodal transfer but had significantly differed in converting temporally distributed stimuli into spatially distributed stimuli within the same modality. In task two, it was demonstrated that this difficulty was not due to inaccurate perception of the stimuli. The two groups did not differ when required to match the whole visual light pattern (displayed at one time) with the dot pattern. Near perfect scores were obtained from both groups. The child was asked how he had matched the light pattern to the dot pattern in task one. Children varied markedly in their reports of their coding systems which enabled them to achieve the appropriate (or inappropriate) conversion response.

Task three tested their verbal labeling more directly by having the Ss verbalize only the exact sequence in which the lights were flashed. Errors were scored when the verbalization was not exact in describing the pattern. RR performed significantly less well than the NR ($P < .005$). The specific errors made by RR were both in recalling the number of lights and in the placement of the pauses. It was concluded that RR do not necessarily have difficulty with A or intramodal processing as much as having an inability to apply conceptual categories or the correct verbal labels to temporally presented stimuli. Thus, these results suggest an alternative hypothesis for the causes of RRs' poor performance on A and AVI tasks. Since all Ss were capable of number coding (but the RR did not apply such coding effectively), the authors postulated the existence of a possible attentional deficit. "Such an attentional deficit, if it exists, would affect a wide range of perceptual and cognitive processes since it would interfere with children applying the knowledge they already possessed and thus, also interfere with acquiring new skills (e.g., reading)." (p. 845). [For an extensive review of the literature on attentional deficit hypothesis, see Ross, 1976, pp 38-60.]

In a subsequent investigation (Blank, et al, 1968), it was hypothesized that temporal stimuli, whether visual or auditory, could not be utilized unless coded into a number system. Since RR were found to have significantly greater difficulty in applying verbal labels to physical stimuli characteristics, they would evidence cross-modal deficiencies which were, in fact, a failure to code accurately the temporally presented components of a task. A basic conceptual, rather than perceptual, deficit may be the cause of reading retardation. Four tasks were administered to first grade NR and RR (matched for IQ) to test for equivalence abilities between temporal-spatial stimuli, perceptual abilities, accurate verbalization of events, and rhythm perception. The latter was a previously proposed cause of AVI deficiency in RR Ss. The result again demonstrated:

> "...that difficulties in perception per se are not associated with reading retardation, whereas difficulties in transforming stimili into a coding system are so associated... this deficiency may be responsible for the poor performance of young reading retardates on tasks which seemingly are perceptually based. These findings suggest that attempts to prevent reading difficulty should perhaps not emphasize perceptual training but rather focus on techniques to develop abstract thinking." (p. 833).

It was further noted that all "auditory stimuli are of necessity temporal and therefore demanded a coding process," in which RR appear to have deficient abilities (p. 833).

Goodnow (1971) has argued similarly that accurate performance on AVI depends on the ability to translate the time intervals between the dots. She found that it is only at about age seven that children are able to make such translation spontaneously. Furthermore, evidence was suggested by Goodnow (in a paper by Stambak, 1962) supporting the proposition that RR may lag behind NR in the age at which translations from temporal to spatial intervals are made spontaneously. Goodnow concludes that performance on perceptual (or integrative) tasks depends jointly on the complexity of the specific tasks and on the nature of the coding used by the child. These would, of course, not be independent of one another, in that certain kinds of stimuli would necessarily demarcate certain kinds of coding (e.g., letters).

Not all results have been positive concerning conceptual-mediational factors as accounting for AVI deficiencies via auditory-temporal deficits. Sterritt and Rudnick (1966) performed a similar experiment with fourth grade boys and found that the ability to transpose auditory temporal to visual temporal patterns is related to reading when IQ is accounted for. The three tasks - Birch and Belmont task, a tape recorded stimulus pattern (A), and a light pattern emanating from one light (V-temporal) were to be compared with dot patterns similar to Birch and Belmont's. The V test did not predict reading scores, and the ability to transpose from temporal to spatial formats within the verbal modality did not appear to differentiate NR from RR. The A test did differentiate NR from RR (A temporal to V spatial). It was concluded that it was the AVI task (cross-modality task) which differentiated Ss and not temporal to spatial comparisons, thus lending support to an AVI hypothesis.

Rudnick and Sterritt (1967) applied similar tests to a population of third grade boys. They found that the V test predicted reading as successfully as the A test, which was not consistent with earlier work with fourth graders. Bryant (1964) reported that visual perceptual test scores decreased as predictors of reading with increasing ages. Thus, these results generally support Blank, et al, on temporal-spatial difficulties, where at fourth grade these difficulties are more specifically related to AVI and previous to fourth grade, perceptual abilities appear more related to reading.

VERBAL LABELING DEFICITS IN AVI METHODOLOGY

Results indicated that only verbal labeling ability of AV stimulus configurations was related significantly to reading scores. Therefore, the major source of difficulty for RR was a deficiency in equating the visual with the auditory symbols. A limited support for the proposal put forth by Blank and Bridger is that verbal labeling is related to performance in AVI. When IQ was held constant, no significant differences were obtained for abilities in AVI (Birch and Belmont's task) and reading for the two different groups. Walters and Doan (1962) also suggested that RR may have a general lack of ability in associating symbols with objects or actions, while Gascon and Goodnow (1971) suggest a deficiency in RR ability in associative naming skills.

It appears that naming ability, the ability to apply verbal labeling or coding (an apparent necessity for equating physically different stimuli - A and V) may be a major factor in performing AVI tasks and also may be of great importance in predicting reading deficiencies.

The above cited studies, although not completely consistent, do tend to support the fact that AVI of Birch and Belmont are not simple cross-modality, intersensory integration skills, but involve complex conceptualization and coding abilities. Some authors (discussed in more detail later) on the basis of these results and their own endeavors, criticize Birch and Belmont's interpretation that the task is a measure of AVI integration or that such a task even relates to linguistic processes (Barnsley, et al, 1973). Two contradictory studies that do not support the verbal labeling hypothesis should be mentioned.

In the first, Kahn and Birch (1968) studied the importance of IQ, V and A discrimination skills, A rote memory, and the application of verbal labels to the physical stimuli as possible mediators of the relation of AVI to reading (abilities). Three hundred fifty boys from grades two through six were given a modified Birch and Belmont task which controlled for floor and ceiling effects at all age levels. Three significant findings resulted: 1) that AVI was positively related to reading ability; 2) that when IQ was partialed out, this relationship was maintained; and 3) that of the four strategies reported by the children when performing the AVI task (about half were counting the groups of taps, while the remainder seemed to be using auditory or proprioceptive memory), those that utilized verbal mediation were the least effective at all ages. Furthermore,

> "data obtained concerning individual differences in V and A discrimination skills, auditory, rote memory, and the use of language in approaching the AVI task indicated that none of these factors by themselves could account for differences in AVI performance...Although Blank and Bridger (1966) have suggested that the ability to apply verbal labels to the auditory stimili is a pertinent variable in mediating cross-modal competence, the evidence of the current study does not support this position." (Kahn & Birch, 1968, pp. 408, 468).

The finding that verbal labels of A temporal stimuli were not beneficial in such tasks is contradictory to previously stated results, and left undiscussed was why such discrepancies were evidenced. One explanation might be that the results were compared across grades and not reading ability; therefore, there may have been confounding of results in relation to RR ability to code verbally information. Only AVI performance was related to coding strategy, and generalization to reading abilities is unwarranted. Still, the fact that children did employ divergent strategies is significant. This implies that different abilities are being tested according to the strategy employed by RR.

In a second study, Gregory and Gregory (1973) devised a new type of Birch and Belmont task which made the inter-stimulus intervals consistent while varying the duration of stimulus presentation (similar in form to the Morse code). Thus, the S is forced to attend to differences in the duration of the stimuli rather than to the intervals between them; hence, a closer analogy to reading. Ss ranges from six years, four months to eleven years, nine months, and both the new task and original Birch and Belmont were presented. A significantly higher correlation was found between the Morse type test and reading ability (r=.51), while the Birch and Belmont task and reading was lower (r=.21). Marked differences were noted in strategies used: On the Birch and Belmont task, 50% reported using counting (verbal labeling) while only 20% did so on the Gregory test. Gregory et al, concluded that this new test provided "a much more direct measure of auditory-visual matching ability (by decreasing effectiveness of verbal labeling)," and the strong correlation with reading supports the idea that this ability is one of the important skills underlying the development of reading. These results also show that verbal mediation is not necessary for coding temporal sequences of auditory stimuli as maintained by Blank and Bridger (1967, p. 1066).

RELATION OF AVI METHODOLOGY TO READING

One final question arises as to whether the Birch and Belmont investigations demonstrate the crucial deficiencies in RR ability to read. Barnsley, et al, (1973) claim that the Birch and Belmont task was not related (did not correlate significantly) to grapheme-phoneme matching abilities as measured by a reading factor, consonant sounding. In this task, the S was required to say the sounds of fifteen consonant letters as quickly as possible. The time taken and errors made were recorded and correlated with results of a Birch and Belmont investigation. Correlations between the two were insignificant. Barnsley, et al, stated: "This observation is taken as strong evidence that this test (Birch and Belmont's AVI task) does not assess visual-auditory, cross-modal integration skills." (p. 16).

Their interpretation supported earlier work (Sterritt and Rudnick, 1966) when it was stated that "the Birch and Belmont test may not be a measure of AVI or even auditory perception." (p. 865). As in the earlier work in A and V perceptual experiments, the possibility arises as to whether the AVI deficiency is more specific to linguistic material. Even though the Birch and Belmont task may be criticized on several dimensions and for interpretations of what this task may be measuring, the AVI hypothesis has not been satisfactorily refuted in any case as a basic deficiency of RR. In fact, even on the basis of Birch and Belmont's results, with more sophisticated methodologies and appropriate controls, the effect remains.

Further support is lent to an AVI hypothesis by the successful techniques that do give remediation through use of specific sensory integration or multisensory integrative approach, e.g., with the emphasis on the integration of visual and auditory senses, and with the addition of the tactile or kinesthetic senses when the RR problem is severe (see Ayres, 1972; Fernald, 1943; Monroe, 1932; Frostig and Horne, 1964; Kephart, 1960). Therefore, the general, well controlled evidence for AVI difficulties stands to be researched as a major causal possibility in research on reading retardation.

APPLICATION OF AVI FINDINGS TO PRESENT INVESTIGATION

These studies indicate that the previously recognized difficulty in AVI abilities in RR is due to deficiencies in dealing effectively with auditory-temporal stimuli. When auditory stimuli are employed, higher order cognitive processes must be utilized to categorize and verbally code such stimuli. The use of temporally distributed stimuli may be one of the reasons for the existence of such discrepancies noted in previous research when using auditory stimuli. When the AVI test is used, if it is susceptible to verbal coding as a means of conceptualizing temporal stimulus configurations (as in auditory stimuli or temporally presented visual stimuli), then the RR are left at a distinct testing disadvantage. RR do not employ spontaneous coding strategies to as great an extent as do NR. In such cases "perceptual" intramodal processing is confounded by deficiencies in necessary coding abilities. These results would explain previous reports of deficiencies in auditory processing for RR, when in fact it appears to have been deficits in processing other characteristics of an auditory stimulus. Whenever a task employs stimuli which are presented temporally, RR demonstrate significant difficulties when compared to NR. One must conclude from a review of related studies that perceptual or integrative tasks have not been assessed without these unforeseen confounding variables. When the importance of verbal labeling is reduced (Gregory and Gregory, 1973), AVI tasks again appear to differentiate RR from NR. The research on temporal to spatial and the consequent necessity of verbal labeling serve to point out several important processes that must be accounted for when studying AVI abilities. Certain controls are necessary before an AVI deficiency hypothesis can be supported or rejected. One might suspect that if AVI processing could be assessed without such confounding variables, higher order integrative processes may again be implicated. A final paper using paired associate tasks and linguistic material adds convincing support to the AVI hypothesis.

Vellutino (1972) stated: "An alternative possibility is that the disabled reader perceives a graphic stimulus accurately and yet mislabels it in oral encoding because of difficulty in associating it with its verbal counterpart." These types of errors (b to d, was to saw, etc.) could, as the researchers go on to point out, "more accurately be deciphered as generalization errors due to imperfect learning rather than perceptual distortions resulting from specific neurological disorders...whether the major deficit occurs in the storage or the retrieval aspects of auditory-visual integration is unclear." (p. 107). In the following experiment they demonstrated that RR do not experience perceptual problems when viewing letters, but in misreading them, or more accurately, misgeneralizing on the correct forms perceived. Clinically, these errors are mistaken for and appear to be perceptual difficulties, and therefore, may account for why "perceptual" difficulties are demonstrated when using linguistic stimuli.

Thirty-four fifth grade Ss were selected for RR and NR groups (thirty-two boys and two girls). The criterion for membership in the RR group was that the reading scores from two standardized tests be at least two or more years below grade level. There were no significant differences in age, grade level, performance IQ and full scale IQ. (However, there were significant differences in reading and verbal IQ scores between RR and NR groups.)

All Ss were presented with twenty stimuli shown for a duration of 600 msec. each. They were comprised of: three shapes (triangle, diamond, and the Greek letter, psi); two, three digit numbers (251 and 684); three scrambled letters sets (hnr, pgbj, and dfijb), and twelve words (bin, cod, pod, tow, beef, snug, form, quart, ankle, meter, and dodge). As is evident, the scrambled letters were chosen on the basis of their similarity in appearance to provide amply opportunity for the type of orientational and perceptual errors that are clinically observed in RR. Ss were required to copy each of the twenty stimuli presentations from memory. Then only the word series was re-presented and the Ss were instructed to read aloud the word that appeared; (the Ss were allowed fifteen seconds to do so before an error was scored). Lastly, the S was asked to spell each word on the list.

Results demonstrated that NR and RR did not differ in accurate reproductions of designs and numbers (thus supporting earlier evidence that RR do not differ in their perception of complex geometric forms and digits, Schilder, 1944; Benton, 1962). The data from copying four and five letter sets were too low to compare groups, but from the results on three letter groups they concluded that "poor and normal readers did not differ appreciably in the copying of the scrambled letters...A more detailed analysis of the scrambled letters yielded no statistically significant difference in the total number of spatial reversals, sequential reversals, substitutions, omissions or additions." (p. 11). Although both groups could copy words better than they could read them aloud, only in the latter task did RR clearly perform significantly worse in V to A transportation than NR, and demonstrated their characteristic difficulties (each word length of oral reading was significantly different. Yet there were no significant differences between NR and RR for copying three and four letter words (p. 113). The characteristic reversals (spatial and sequential), inversions and omissions, etc., of RRs seem present only when the RR child is required to encode grapheme to phoneme matches (as suggested by Barnsley, et al, 1973). For additional support of the AVI hypothesis, see Katz and Deutsch (1963); Rabb, Katz, and Deutsch (1960) [who employed cross modal reaction time tasks]; and Senf, et al, (1969, 1970, 1971) [who used bisensory memory tasks (similar to Broadbent's dichotic listening procedure)] , who all found intermodal processing deficient in RR independent of intramodal processing.

In summary, these results lead to an obvious extension of previous AVI research: using a Birch and Belmont paradigm and general procedure, controlling for age, sex, IQ, and the possibility of intra-modal deficits in letter matching. One would expect that NR and RR would be relatively equal in their perception of stimulus events within each mode (AA and VV intrasensory perception), but deficient in relation to NR when information from two different modes -

auditory and visual - was required to be processed simultaneously to compare stimulus events (AV and VA intersensory integration). The purpose of the present investigation is to examine intra vs. intersensory integration abilities in NR and RR using linguistic (letter matching) material.

Certainly, one final possibility remains that may explain discrepancies in the research on intramodal or intermodal deficiencies as the major contribution to RR: that is the distinct and clinically observable (through known assessment procedures) possibility that RR suffer from both types of deficiencies. Some have difficulty perceiving auditory or visual stimuli; others, who perceive accurately and efficiently, have difficulty processing or transforming that information to usable or appropriately required forms.

At least two major groups of RR could be distinguished: those that evidence perceptual difficulty (i.e., not perceiving information accurately) should necessarily evidence AVI difficulties; a second group may exist that perceives as accurately as NR but fails to encode effectively, decode, transform perceptual information from one mode to another. If this were the case, researchers comparing intrasensory processing with intersensory integration in RR could be expected to have difficulty in achieving comparable and conforming results. Statistically, using two such heterogeneous groups as one (RR) would factor out individual differences and deficiencies. It may be that some have intramode-perceptual processing difficulties and also manifest AVI deficiencies, while others achieve perceptual normalcy but are inferior in cross-modal performance only. In experiments stressing the former, one would expect auditory or visual components to be responsible for AVI deficiencies, where, in the latter they would appear to be independent. In either case, AVI functioning would be lower for RR than NR. This hypothesis parallels the general pattern of results and explains another possibility in accounting for conflicting equivocal and ambiguous results.

There are three possible reasons for data evidenced thus far: 1) that there exists a genuine AVI deficit in all RR which accounts for a significant proportion of the variance in predicting reading difficulties. Results contrary to this AVI deficiency are inaccurate due to extant methodological problems.

2) results are due to higher order conceptualization factors which mediate AVI abilities, so that verbal mediation ability is a prerequisite to accurate AVI functioning. The one important factor here is an inability to deal effectively with temporally (which is generally auditory)

distributed stimuli, and to transfer these signals to a meaningful and applicable code.

3) the results are due to deficient auditory, visual and/or integrational difficulties in which any one S may suffer from any one or combination of the three. Any of these or any combination thereof could account for results thus far reviewed.

One may ask whether a significant AVI deficit could be demonstrated if a more direct measure could be designed. How could one minimize the major confounding variables of the Birch and Belmont task: the effects of temporal characteristics and the differences in verbal coding strategies between NR and RR? An answer to both is to use: 1) overlearned material, i.e., stimuli that would be coded in the same manner for all Ss; and 2) stimuli which would carry the same information whether presented via A or V mode and in which the V stimuli could be temporally presented in the same way as the A presentation. If this could be achieved, one would eliminate or reduce the major confounding variable demonstrated in the literature on AVI processing, and therefore more accurately assess the importance of perceptual or integration deficits in RR. To achieve these goals and improvements, one could utilize linguistic material, e.g., letters in a matching letter task. What would be required of the S is that he be familiar with letter shapes and names. Both stimulus characteristics remain invariable and would implicitly necessitate consistent verbal coding strategies by all Ss. Further, no encoding or decoding (to verbal or graphic representations) of stimuli would be required. Thus, they would be left unconfounded by possible difficulties in grapheme-phoneme associations. To ensure that the task is not confounded by V and A discrimination problems (a subject for further research), minimally confusable letters could be employed, i.e., capital consonants.

EXPERIMENTAL HYPOTHESIS

By employing the above suggested stimuli in a match-to-sample recognition task both within and between all combinations of A and V (VV, AA, VA, and AV), one would hypothesize that the integration tasks would be significantly more difficult for RR than NR. Further, one would expect on the basis of the above research that perceptual functioning (under these controlled conditions) would have a minimal effect on AVI abilities.

One might interject that perceptual difficulties still might be what RR suffer from and thus "known" reversal and inversions are influencing errors of the letters themselves (Orton, 1937). Therefore, one must include an intrasensory condition to check for such difficulties.

CONSIDERATIONS: IQ, AGE, AND SEX

In research concerning AVI processing, several variables must be controlled and will be accounted for in the present investigation. Among the most important are subject characteristics, i.e., intellectual level, age, and sex. On the basis of previous research, it was decided to match Ss on IQ (not below 90 on Verbal IQ) and to employ only third grade boys (ranging in age from roughly eight to nine years).

There seem to exist opposite age trends between AVI and reading ability and between IQ and reading ability. The association between AVI and reading is strongest in youngest age groups and decreases over age, whereas the relationship between IQ and reading is lowest in the youngest age group (at fourth grade and above) and becomes more highly correlated in older age groups. McNinch and Richmond (1972) showed that normal IQ levels are not significantly related to reading achievement at younger ages, where "IQ was only able to add 3% to one prediction (of reading)." (p. 11). After fourth grade, IQ becomes strongly related to reading success.

Other studies support that when IQ is accounted for, a significant relationship is maintained between AVI and reading for RR in fourth grade boys (Reilly, 1971; Kahn and Birch, 1965), and that IQ has been demonstrated to relate to both integrative functioning and reading abilities in subsequent studies (Kahn and Birch, 1968; Ford, 1967; and Lawton and Seim, 1973); however, Sterritt and Rudnick (1966) found that AVI performance was related to reading ability independently of IQ (average IQ scores, as measured by Lorge-Thorndicke, were over 100 - p. 862). They further demonstrated that by the second grade 80% of AVI abilities appeared to be developed. By fourth grade approximately 90-95% efficiency in AVI functioning was demonstrated. These results supported earlier findings by Reilly (1971, p. 485) who found that asymptote in AVI functioning is reached by fourth grade level.

The use of male subjects is indicated by the well known differences in academic abilities and achievement between males and females. More specific to AVI, Reilly (1971) demonstrated that females are superior to males in AVI development. It has also been well established that the frequency in males is far greater than in females by approximately four to one (Wagner, 1971; Hartstein, 1971; Goldberg, et al, 1972; Learner, 1971). Also, male Ss have been used exclusively in a vast majority of the studies reviewed. (See Wiener, et al, 1970; Reilly, 1971; and Gregory, et al, 1973).

Results reviewed so far indicate that for the least possible confounding, Ss should be for convenience: 1) male; 2) matched for IQ (which should be above 90 so that mental deficiencies are not a confounding factor); and 3) range in age from roughly eight to ten years (third or fourth grade).

CONSIDERATIONS: VISUAL AND AUDITORY MEMORY

In the present study a matching-to-sample recognition task was selected as the most appropriate means of comparing RR to NR. The primary advantage of the recognition task is its minimal demands on auditory and visual memory; thus these variables are less likely to confound results obtained. Recognition task also is most like the educational process which depends on accurate recognition of visually and auditorily presented information (Carterett and Jones, 1967). Lastly, recognition tasks have been the predominant design utilized in AVI studies on RR and NR.

It should be noted, however, that recent studies have indicated that immediate auditory and visual memory have not been found to influence the differential performance of AVI tasks between RR and NR. Birch and Belmont (1964, 1965) found that both groups performed equally on an auditory recall task (Digit Span subtest of the WISC). Voort, et al, (1972) investigated specifically whether differential memory for the initial auditory or visual patterns might explain RR's inferior performance on matching tasks. Using a task design similar to Beery (1967) - like the Birch and Belmont task except using "same-different" responses and employing intramode control tasks - they found that greater delays between initial and comparison stimuli (either 3 or 6 second delay) made no significant differences in results obtained. Even when presented simultaneously, virtually eliminating short-term memory demands, RR still performed significantly more poorly than NR. Thus differences in duration between the stimulus and response made no difference in results, which appears to eliminate A or V immediate memory differences as a possible explanation of RR poor performance on AA, VV or AVI tasks. Similar results were obtained by Dornbush, et al, (1970), Clifton-Everest (1974), Vellutino, et al, (1975), and Davis and Bray (1975). It therefore appears that immediate memory functioning is not a significant factor in RR and thus cannot account for their inferior performance on AVI tasks.

CONSIDERATIONS: LINGUISTIC VS. NON-LINGUISTIC STIMULI

Vellutino, et al, (1973) and Dornbush, et al, (1970) have suggested that using letters and verbal stimuli may yield different results than employing non-linguistic stimuli and RR may have integration difficulties unique to linguistic characteristics.

The advantages of using linguistic material (letter recognition) are that one can assume that the stimuli will be overlearned (by the second grade and certainly by the fourth). Therefore they should: a) be verbally coded in a similar manner across Ss; b) minimize temporal-spatial differences (minimizing earlier confounding variables); c) if differences in AVI processing using overlearned material are found, stronger support would be given to this hypothesis than the use of novel stimuli (which may be a confounding variable in itself). Additionally, because the deficiencies observed are in dealing with linguistic material and because the ultimate goal is both to have an accurate understanding of the processing deficiencies of RR and to develop more efficient and appropriate remedial techniques, results from such a study would be particularly useful. In short, the reading difficulty is being investigated directly.

It has been demonstrated using an improved Birch and

Belmont (Morse Code task) that when more direct measures of AVI processing are employed (by minimizing verbal coding differences between RR and NR) that an even greater correlation between AVI and reading emerges (Gregory, et al, (1973). If similar improved results are demonstrated using linguistic material (which one would expect), then the existence of an AVI deficit will be demonstrated as a generalized deficit experienced by RR. In view of the previous research, it seems time to begin extending those results and techniques to a more direct investigation of the problem, i.e., the RR's difficulty in dealing with the processes involved in reading and writing.

METHOD

SUBJECTS

The reading-retarded Ss were selected from four schools which specialized in or had departments for the remediation of reading deficiencies. Twenty male Ss were selected using the following criteria: a) IQ above 90 as measured by the WISC Verbal IQ; b) exclusion of Ss with known gross neurological, sensory or emotional problems; c) reading quotient retarded at least one year - estimated by the averaging of scores on the Slosson Oral Reading Test and the Durrell Analysis of Reading Difficulty - oral and silent reading subtests; and d) age range of eight to nine years.

The twenty male control Ss (normal readers - NR) met the same criteria outlined for the RR except: a) they attended public elementary school and b) they were required to have adequate reading skills (at or above age-grade level as measured by the same reading tests mentioned above). These Ss matched RR on obtained WISC Verbal IQ scores.

MATERIALS AND TESTS

All Ss were given the Verbal Performance subtest of the WISC and the test of Visual Sequential Memory (a subtest of the Illinois Test of Psycho-linguistic Abilities - ITPA). The ITPA was employed in a modified manner to check for both sequential and rotational errors. Dependent variables on this subtest consisted of the number of sequential errors made as well as those errors of rotation of the geometric designs. After two successive failures to complete any one trial, the test was terminated, and rotational and sequential errors compiled and recorded. The test was administered to identify Ss with possible perceptual-memory difficulties. This provided a pretest check for those who might be observed to have intrasensory difficulties in the testing situation.

The experimental task testing inter and intrasensory abilities consisted of fifteen pairs of stimulus sets that were prepared on both slides (Visual - V) and recording tape (Auditory - A). Each of the original and comparison slides and tape sets were composed of one set of three (consonant capital) letters. For each trial the S was presented with one original and four separate comparison sets (presented sequentially) of which only one was identical to the original. The other three were randomly selected sets of letters. The S responded by identifying the original set from the comparison sets.

Four tests were employed involving all combinations of intrasensory and intersensory matching-to-sample recognition; the intrasensory matching tasks were as follows: 1) Visual to Visual (VV); 2) Auditory to Auditory (AA) and intersensory matching; 3) Visual to Auditory (VA); and finally 4) Auditory to Visual (AV). All forty Ss received all four conditions.

To counterbalance for order effects of conditions both groups of Ss (RR and NR) were randomly subdivided into four groups of five Ss. Group one received VV, AA, AV, VA
Group two received AA, VA, VV, AV
Group three received AV, VV, VA, AA
Group four received VA, AV, AA, VV
(Zigmond, 1966)
Each condition contained fifteen trials.

DESIGN

This study involves a 2 x 4 factorial design with repeated measures on one factor (experimental conditions). There are two types of readers (RR and NR), and four levels of experimental conditions (VV, AA, VA, AV). Forty Ss received all levels of conditions. A Latin square was employed to counterbalance order effects over all (A and V) conditions (Zigmond, 1966). [See above.]

Each S was required to make a match-to-sample response for every trial in each condition. In the VV condition the original slide was presented for a duration of 700 msec. followed by a 1400 msec. interim period and then the four comparison stimulus slides were presented sequentially. Each of these was also presented for a duration of 700 msec. with a 700 msec. interstimuli interval. Only the subject's first response was scored, correct or incorrect. The intertrial interval was five seconds.

The same procedure for the AA condition was followed; that is, the S heard the original set of the three letters followed by the four sets of comparison stimuli, and then he identified the matching sets.

In the intersensory trials the same procedure was also followed. For the VA condition, the S was presented with the original target slide followed by the four auditorily-recorded comparison sets. Conversely, in the AV trials the S first heard the original auditorily-recorded set which was followed by four visual-slide comparison sets.

The order of correct and incorrect comparison sets was varied randomly, across trials. The time duration and intervals for the V conditions were selected to approximate the same time duration and time intervals as the A conditions.

Therefore all conditions were presented over a temporal dimension to control for possible spatial-temporal differences noted earlier.

EQUIPMENT

All time variables were accurately controlled and precisely consistent for all Ss. The system consisted of a Craig 2408, two track, reel-to-reel tape recorder; a Kodak Carousel 850 slide projector; and a Kodak Carousel Sound Synchronizer. All time intervals were triggered by a Lafayette Interval 5040B timer. Track A carried timed pulses which triggered all visual-slide displays (necessary for VV, VA and AV conditions). Track B carried all auditory information (necessary for AA, VA and AV conditions). Therefore, all conditions were timed and integrated accurately to be consistent for both A and V stimuli over all Ss. Craig-Superior headphones were worn by all subjects to eliminate extraneous noise and to decrease distractability.

PROCEDURE

Each S was familiarized with the testing room before entering it with the experimenter (E). While standing beside S's chair in the room, E administered the first instructions. Regardless of which condition was presented first, E said, "I am going to show you some letters on this screen. First I will show you a few so you can get used to seeing them. When you see the letters I would like you to say them to me. Don't worry if you make a mistake; this is only so you get used to seeing them." After five sets were given, the E instructed the S as follows: "Now you will hear three letters. Right after you hear the letters, say them right back to me. There will be several trials so don't worry if you make a mistake. I just want you to get used to hearing the letters. Here is the first one." This procedure was added to ensure that the letters were processed accurately, so that it was known that the child could deal effectively with the task and was familiar with the letters.

If the first task was the intrasensory VV condition the instructions were: "Now I am going to show you another set of letters, but this time they will stay on for a shorter time. After the first one goes off it will be followed by four other slides of letters. Some slides will be different from the first one, but one will be the exact same. I want you to tell me or show me which one is the same as the first one. We will have a few practice ones in which I will help if you need it. Do you have any questions?" The E helped the S understand what was expected of him and gave him feedback on how he was doing during practice trials.

If the S had difficulty with the task or waited too long, the E said: "Remember, you have to pick the one that is exactly like the first one as soon as you see (or hear) it. Let's do the last one together." The E showed the same slides again, original and comparison slides, going through each of the comparison slides asking, "Is this one just like the first one we saw?" This questioning was done until the S made the correct response. Two practice trials were presented before each testing condition (VV, AA, VA, AV) began.

If an intersensory task was presented (for example VA), the instruction was: "This time you will see some letters on the screen, just like before; this time you will hear four sets of letters right after the ones on the screen go off. Some of the sets you hear will be different from the one you saw, but one will be exactly like the one you saw. I'd like you to tell or show me which one is exactly like the first one. Let's practice a few. I will help you if you need it. Here is the first one." The remainder of the instructions for this task as well as the AV task was similar to the intramode task instructions.

After every S completed the fifteen trials of each of the four conditions, results were recorded and compiled.

RESULTS

Analysis of the present investigation was carried out in three phases. Separate single factor F ratios were computed to determine the significance of pertinent criterion variables to ensure that RR and NR do not vary on extraneous factors. Then, the major hypothesis was investigated by subjecting the results of the VV, AA, VA, and AV tasks (by NR and RR) to a 2 x 4 analysis of variance (2-way ANOVA). Finally, a correlational study was conducted to determine the relationship between intrasensory and intersensory data and reading, memory, and IQ scores. All were completed using the Statistical Package for the Social Sciences (SPSS) program.

RESULTS OF CRITERION VARIABLES

As can be seen in Table I, no significant differences between RR and NR exist among any criterion variables of age, IQ, and memory functioning (visual sequential or rotational or auditory sequential). Spelling and reading, both silent and oral, were not computed because they would result in significantly divergent T values as these tests were utilized in the selection criterion of types of readers (NR and RR).

Overall, the results of criterion variables demonstrate that any effect shown in A/V and AVI tasks was not due to age, IQ, or the various types of memory tested. The variables aforementioned seem to be the most important for control purposes as emphasized in the literature and summarized in the Introduction. These variables would, therefore, not influence the following experimental test results to any significant degree.

ANALYSIS OF AVI EFFECTS ON RR AND NR

According to the hypothesized result stated in the Introduction, one would expect a significant interaction between the four experimental A/V combinations over conditions and the two types of readers (Factor A and B, respectively).

An Analysis of Variance for a 2 x 4 factorial design with repeated measures on one factor [VV, AA, VA and AV] was conducted to determine the significances of trial conditions, type of subjects (Nr and RR), and interaction of these two variables. The results of this analysis are presented in Table II. It should be noted that the interaction effects and both main effects were significant.

The significant interaction effects illustrate that the effects of the stimulus combination on the dependent variable (number of correct recognition responses per condition) differs for the different type of subject (NR and RR). It is apparent from the data (and Graph I and Graph II) that the effects of stimulus conditions, particularly in the integrative modes (VA and AV), affect RR performance more than NR performance.

Because of the highly significant F values for the main effects (F= 29.47 for Factor A and F= 99.15 for Factor B), it is of considerable value to investigate the sources of variance within the levels of these two factors, keeping in mind that a highly significant interaction, A x B*, was obtained and therefore caution is exercised in interpretation because of the unique manner by which one factor influences the other.

Justification for importance of the main effects stems from the fact that an ordinal interaction exists (Keppler, pp. 204, 205). As can be seen in Graph 1a and 1b, the linear functions do not intersect; therefore an ordinal interaction exists rendering the main effects interpretable.
The factorial levels of A (conditions for VV, AA, VA, AV) are consistently greater for NR than RR.

*A - test conditions: VV, AA, VA, VV
B - types of readers: NR, RR

A more detailed analysis of the differences between groups over each VV, AA, VA and AV conditions was performed. Values were compiled for all conditions over Ss. Table III presents the data. VV, VA and AV were significantly different for NR and RR beyond the $P<.001$ level while AA reached $P<.01$ criterion. These data indicate that at all levels of processing (both perceptual and integrative) RR were significantly more deficient in their abilities to equate Auditory and Visual linguistic information.

Because of the consistency to which this indication is true, it is possible to rank order for clarity, the degree of relative (NR to RR) difficulty in processing information under the various conditions (see Graph la for descriptive breakdown). AA condition is the least discrepant, but more difficult than VV, followed by VA and finally AV, which demonstrated a high degree of deficiency in RR to equate Visual stimuli to an Auditory target stimulus.

RESULTS OF CORRELATIONAL ANALYSIS

A correlational matrix was compiled to investigate the relationship between experimental conditions (VV, AA, VA, and AV), reading, perceptual-memory functions (Sequential and Rotational), and IQ for all Ss. The results are illustrated in Table IV.

Reading and all experimental condition scores significantly correlated (VV, r= .4298, P<.005; AA, r= .5563, P<.001, VA, r= .5923, P<.001; AV, r= .6396, P<.001). This finding demonstrates that all levels of perceptual and integrative linguistic functioning are positively related to reading.

Correlations between all experimental conditions, with the exception of the VV condition, and IQ scores were non-significant. VV conditions and IQ scores were negatively correlated (VV, r=-.2695, P<.05). Therefore, while no relationship existed between AA, VA and AV, those that scored higher on IQ generally performed lower on the VV task.

Performance on experimental conditions, at all levels, and perceptual memory functions (both sequential and rotational) were not significantly correlated. These findings illustrate that performance on the perceptual and integrative conditions (VV, AA, VA, AV) was not related to perceptual memory scores. It is interesting to note that perceptual memory (rotational and sequential) and reading were not significantly correlated.

Experimental conditions were correlated with reading but did not reach significant correlation with perceptual memory or IQ (except at VV). The experimental conditions were also correlated with one another. All conditions were correlated with other conditions, both within and across perceptual and integrative conditions, with the exception of VV and VA. Within experimental conditions, the correlations were highly significant between VV and AA ($r= .3949$, $P<.06$) and VA and AV ($r= .6830$, $P<.001$), indicating that those with high performance (or low performance) on either perceptual or integrative tasks were likely to have similar scores or other modes or combinations of mode tasks. Between experimental conditions, the results are less clear. Performance on the VA condition was not related to performance scores on the VV condition, while the AA condition reached a relatively moderate but high level of significance ($r= .3675$, $P<.01$). Scores on AV task and VV and AA were both highly significant ($r= .4194$, $P<.005$; $r= .4117$, $P<.005$, respectively). Therefore, within perceptual or integrative modes, scores were consistent across all Ss.

On the other hand, scores are less predictable or not at all in the relationship between one's functioning on a perceptual task to an integrative task.

Because reading, memory, and IQ were all criterion variables (with reading representing a mean score over oral and silent reading scores; memory function, over sequential and rotational on one test; and IQ, only the verbal score), some caution must be exercised when interpreting these results. At the very least, they represent the direction and relative relationship between variables and, as such, have been included in this study.

Graphs I and II illustrate the significant difference between RR and NR groups over the two intra and intersensory tasks. Graph II specifically demonstrates that many RR performed adequately in the intrasensory tasks; in fact, many scored above the NR mean on VV and AA tasks. This is not the case in the two intersensory conditions; none of the RR reached the mean performance achieved by NR. This illustrates the increased difficulties RR had with intersensory tasks.

TABLE I

T Scores and Probability Levels for Criterion Variables

Variable	Type of Reader	Mean	Standard Deviation	T. Value	P Level
Visual Memory	NR	18.6	3.692	.240	NS
Sequential Errors	RR	19.2	4.017		
Visual Memory	NR	4.90	2.614	.893	NS
Rotational Errors	RR	6.1	3.977		
Auditory Memory	NR	10.4	1.953	.498	NS
WISC/D.S.	RR	10.2	1.861		
IQ: Verbal	NR	107.75	9.489	.473	NS
	RR	109.75	7.813		
Age	NR	8.5	1.757		
	RR	8.8	3.456	.368	NS

TABLE II

Analysis of Variance for 2X4 Factorial Design

Source of Variance		Sum of Squares	d.f.	Mean of Squares	F	P Level
A	conditions	182.62	3	60.87	29.47	$< .001$
B	type of Ss	252.51	1	252.51	99.19	$< .001$
AXB	conditions X Ss	49.11	3	16.37	7.92	$< .001$
Error within conditions		235.52	114	2.06		

TABLE III

T Scores and Probability Levels for Experimental Conditions

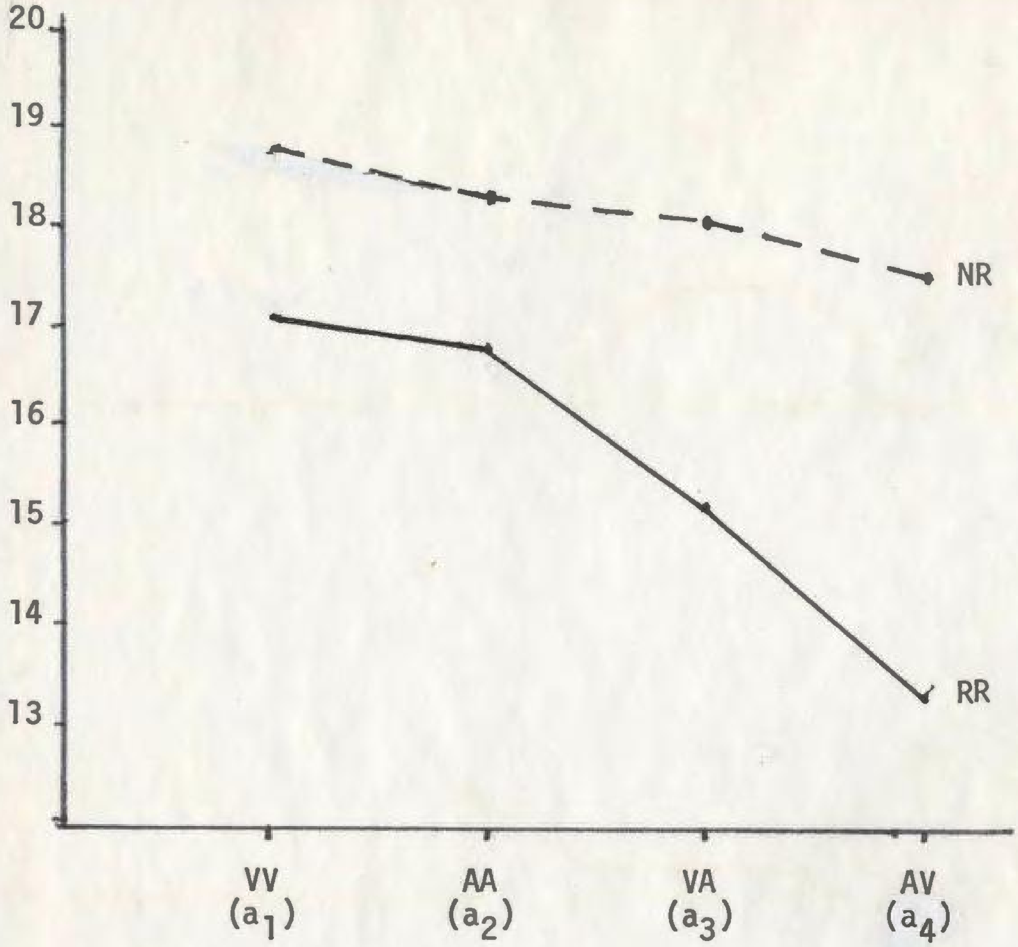
Variable	Type of Reader	Mean	Standard Deviation	T Value	P Level
VV	NR	18.8	.639	4.48	< .001
	RR	17.1	1.518		
AA	NR	18.1	1.020	2.70	< .01
	RR	16.7	2.080		
VA	NR	18.0	1.146	6.28	< .001
	RR	15.2	1.631		
AV	NR	17.2	1.919	8.06	< .001
	RR	13.0	1.322		

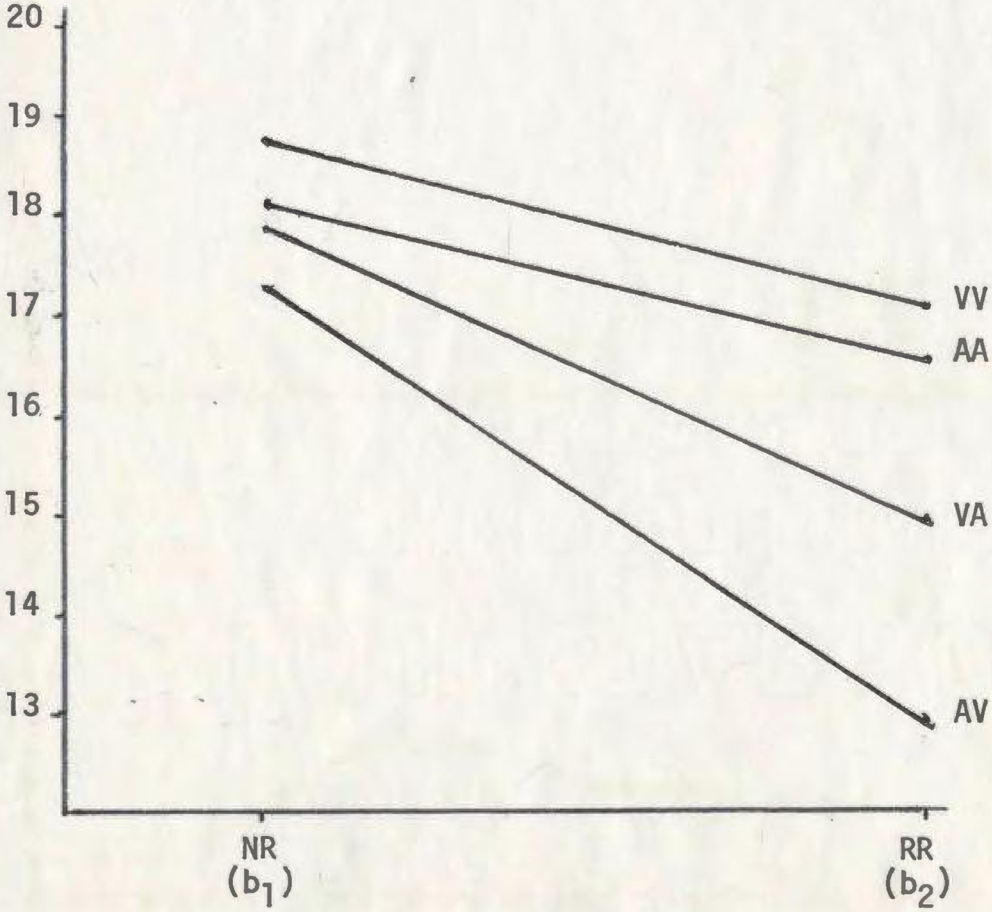
TABLE IV

Pearson Correlation Coefficient Matrix:

Experimental conditions, reading, visual memory and IQ scores

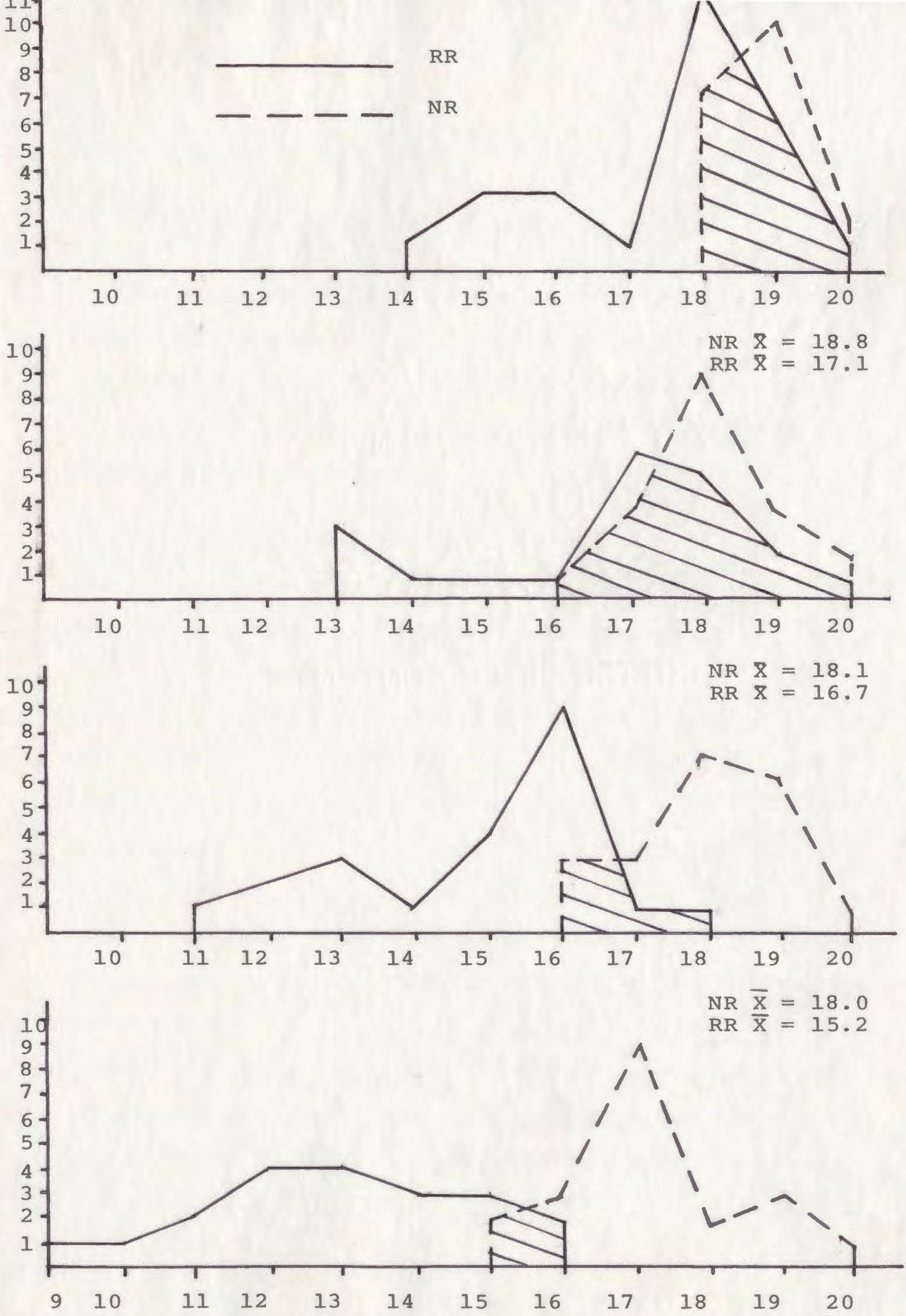
	AA	VA	AV	Reading	Visual Memory Errors Sequence	Rotation	IQ
VV	r=.3949 p=.006	r=.1649 p=.155	r=.4194 p=.005	r=.4298 p=.003	r=.2322 p=NS	r=-.0319 p=NS	r=-.2695 p=.046
AA		r=.3675 p=.01	r=.4117 p=.004	r=.5563 p=.001	r=.0610 P=NS	r=-.0932 p=NS	r=-.0650 p=NS
VA			r=.6830 p=.001	r=.5923 p=.001	r=.0302 P=NS	r=-.1261 p=NS	r=.0007 p=NS
AV				r=.6396 p=.001	r=-.1364 p=NS	r=-.0698 p=NS	r=.0115 p=NS
READING					r=.0651 P=NS	r=.0488 p=NS	r=.0077 p=NS
SEQUENCE						r=.1513 p=NS	r=.1795 p=NS
ROTATION							r=.1290 p=NS





GRAPH I

Interaction Effects: Type of Reader and Performance on Experimental Conditions.



GRAPH II NR X̄ = 17.2 RR X̄ = 13.0
Perceptual and Integration Performance Overlay (NR and RR)

DISCUSSION

SUPPORT OF INTERSENSORY DEFICIT HYPOTHESIS

The intent of this investigation was to support or refute Birch and Belmont's (1964) original hypothesis that contends: The primary disturbance among RRs is their relative inability to transform and make equivalences between the auditory and visual modes.

Since 1964 many assumptions, implications and criticisms have been stated on the basis of Birch and Belmont's research. Among the most crucial have been: 1) the lack of intrasensory controls (Muehl and Kreminak, 1966; Vande Voote, 1972); 2) the employment of stimuli with which comparisons had to be made, not only between auditory and visual modes, but also between temporally and spatially distributed modes (Blank and Bridger, 1966; Goodnow, 1971); 3) the stimuli's susceptibility to verbal coding; 4) the Ss' sequencing ability (Blank and Bridger, 1968; MacKinnon, 1973); and finally 5) the fact that most AVI research has employed stimuli of questionable value to the educational learning process, e.g., non-linguistic material (Barnsley, et al, 1973). In the present investigation, attempts have been made to control or assess for factors that form the basis for such criticisms.

The design of this experiment specifically assessed both RR and NR functioning on intra and intersensory processing of linguistic material, where the demands of memory functioning were decreased through the employment of a match-to-sample recognition task. To support the above hypothesis one would expect a significant interaction between type of Ss (NR and RR) and the experimental conditions (VV, AA, VA, AV). Further support would depend on significant differences between RR and NR at AV and VA conditions. In both cases, expectations were confirmed. Previous results using nonlinguistic tests of AVI have been duplicated and supported using linguistic material and controlling for important, possibly intervening, variables mentioned earlier. Therefore, the relationship between AVI abilities and types of readers has been demonstrated consistently (Birch and Belmont, 1965; Beery, 1967; Kahn & Birch, 1968; Reilly, 1972; Voort, Senf, and Benton, 1972; Bryden, 1972).

There is some question as to the present possibility of ceiling effects among NR on intra and intersensory task performances. Three different pilot studies were conducted using five NR and five RR. These were necessary to modify the tapes that triggered and controlled the auditory and visual presentation time and interstimulus duration. It became apparent that when presentation time was fast enough for attaining a normal distribution for NR, it was too difficult for RR (floor effects were evidenced). Those slow enough to achieve normal distribution in RR produced ceiling effects in NR. A moderate presentation time was selected to achieve adequate distribution in RR and close to ceiling effects for NR. This is not considered to have significantly affected the predicted results or interpretation. The fact that there was such a difference in AVI abilities between RR and NR (although results from previous pilot studies have not been reported) on intersensory tasks further strengthens the support for AVI hypothesis.

To test specifically the relationship between AVI ability and reading abilities, a correlation between reading and VA and AV scores revealed in both cases significant levels. This indicates that test performance on AVI recognition tasks is highly predictive of reading scores and abilities. These results do not indicate causal relationships between AVI deficits and reading disability, but because of the nature of one's ability to read (and write), which is a decoding (or encoding) process, from visually presented stimuli - i.e., letters (or auditory stimuli) to auditory-verbal (or visual-motor) equivalencies - it seems a reasonable conclusion that the relationship may be direct and causal. If an individual demonstrates an inability to make accurate equivalence judgements (using well overlearned letter naming skills) between visually and auditorily presented linguistic information, it is likely that he would be unable to form readily and efficiently the learned associations between symbol and sound, phoneme and grapheme combinations necessary to achieve literacy.

> "A complicating factor in reading...is the mediating step required in turning visually printed symbols into oral language symbols to which ultimately meaning is attached. In the classroom the subskills in this mediating step are called word recognition skills. The relative ease with which children acquire the word recognition skills is the factor that brings about the greatest differentiation in achievement at the beginning stages of academic learning. Some individuals acquire these word recognition skills and raise them to an automatic level of operation...On the other hand some do not pick up this ability to turn visual symbols into oral language and these learners flounder at or near the very beginning stages of reading." (Hartstein, 1971, p. 79).

It should further be noted that significant relationships were also demonstrated between VV and AA and reading abilities. This would be expected as auditory and visual abilities are the primary functions necessary for acquiring reading skills. It would therefore follow that there would be a close and predictable relationship between these abilities and reading.

The results of prevalence of AVI deficiencies in RR are represented in Graph II. This graph demonstrates that in both AV and VA equivalence tasks, RR - in all cases - fell below the mean performance of the NR. When RR were required to match visual information to its auditory equivalent (similar to the task of reading) or auditory to visual (similar to writing), they are demonstrably inefficient relative to NR, with whom such a task appears more automatic (see Graph II). These results support the hypothesis that RR are vastly deficient in processing efficiently across modes; thus, the AVI deficit hypothesis has received support.

JUSTIFICATION OF INFERENCES

It has been demonstrated that differences in age, IQ functioning, both visual (sequential and rotational) and auditory perceptual memory factors do not appear to account for these highly significant differences in intersensory functioning between RR and NR.

In fact it is of interest and import that both visual and auditory memory factors and implied attentional characteristics (mentioned as possible components in several etiological theories of learning disabilities) have not been shown to be significant factors in the present study. Both auditory and visual memory were assessed. As in previous AVI studies, the results of the WISC subtest - Digit Span - of auditory sequential memory have been duplicated. (Birch and Belmont, 1968). It appears that auditory memory for RR is not a significant factor (obtained T value = .498. Furthermore, a test of verbal sequential and rotational memory as assessed by a modified use of the ITPA did not result in significant differences between NR and RR. Although in both cases RR demonstrated more errors than NR, these differences did not achieve significant levels (Sequential memory T= .240; Rotational memory T= .893). One must conclude that these crucial factors did not influence performance on task conditions. Because attentional abilities are a large component of such memory tasks, one further assumes adequate attention and memory were not influential factors in obtained perceptual and integrational test scores. Furthermore, because of relatively stable results in experimental test scores across trials, one could rule out motivated inconsistencies among Ss as a discernible factor.

The mean IQ for RR was marginally greater for RR than NR, though not significantly (T= .473). This finding is fortuitous and due to random sampling differences.

There remain alternative explanations which must be considered in detail. By employing two intrasensory conditions (both VV and AA), one can investigate the relationship between (A and V) perceptual and AVI deficits. If Ss do not receive perceptual information accurately, or cannot process efficiently (i.e., perform poorly on AA or VV), an alternative hypothesis could be stated: even though AV and VA deficits have been evidenced by RR, these results would not necessarily be due to higher order integration deficits, but rather would be attributed to perceptual difficulties. Accurate integration is dependent on accurate perception.

The results demonstrate highly significant differences between NR and RR in VV and AA equivalence tasks, as well as AV and VA deficiencies. Therefore, before any definitive statement regarding integrational deficits can be issued, the results must be taken under consideration. The question is, therefore, whether intersensory deficiencies are due in part or in whole to those demonstrating perceptual deficiencies and, therefore, are not receiving accurate information by which effective integration can be achieved.

Both NR and RR evidenced poorer performance on VA and

AV than either AA or VV, and at all conditions RR demonstrated significantly lower performance scores than NR. By turning to descriptive rather than inferential analysis, one observes important differences between RR and NR. First, by employing T scores as standard scores, it can be illustrated that in performance on intersensory tasks, RR were much less proficient than NR in their performance on perceptual tasks. (See Table III and Graph I). The relative difficulty of processing intersensory information was greater than at a perceptual level of processing.

At this point it is important to distinguish whether this decrease in relative performance is due to a generalized decrease in RR ability to process integrative information or is due to perceptual inaccuracies. The descriptive evidence seems to indicate that this may not be the case. Second, Graph II represents the overlap in performance by scores of NR and RR. It is apparent that although many RR fall below NR performance on AA and VV, many also fall well within normal limits of perceptual performance. Some RR scores fall at or above the mean for NR scores (VV, 12 Ss; AA, 8 Ss). In contrast, few RR are within NR limits on intersensory tasks and only one S attained the mean score of 18 correct in the VA condition. This illustration indicates that generally: a) integration tasks are much more difficult to perform than are perceptual tasks relative to NR performance on the same; b) integrational tasks appear to be a better indicator of deficient abilities for RR; and, finally and most importantly, c) although many RR performed adequately on perceptual functioning, all RR performed inadequately on tasks that required integrating and equivalences between two modes of input. For those RR who function as well as or above average NR functioning, this is a significant finding. For those performing below the NR range of perceptual functioning statements concerning integration are obscured.

These results concur with those of an extensive study by Myklebust (in Waltzer, et al, 1973) conducted over a four year period (from 1965-1969). Based on a Learning Quotient (LQ - i.e., the ratio between educational achievement and expectancy, chronological age, years of schooling and IQ), Myklebust found 15% (of 2767 Ss) were learning disabled children. After an intensive evaluation including an assessment of cognitive abilities such as auditory and visual perceptual skills, expressive and receptive language (spoken, read, and written), academic achievement, verbal and nonverbal mental abilities, motor abilities, orientation in time and space, his results demonstrated that:

> "In terms of identification, though experimental groups showed deficits in auditory and visual learning (intraneurosensory processes), the most effective discriminator was facility in relating auditory to visual information (interneurosensory processes). Even the degree of involvement was clarified by this technique [technique utilized was a syllabication test where Ss were required to 'determine the equivalence of auditory and visual work parts'] ; it was more definitive than a battery of commonly used mental tests." (p. 63).

That dyslexic Ss demonstrate deficiencies in perceptual and integrative difficulties within and between A and V modes is significant; but to differentiate RR from NR is crucial and apparently, successful discrimination is achieved only through assessment of their integrative abilities.

Dr. Charles Drake (interviewed on July 11, 1976) hypothesized that, in terms of A-V perceptual and intersensory processing, at least two significant subpopulations of RR exist: 1) those that have deficits in A and/or V perception and therefore (or in addition to) have integrative deficits, and 2) those that function adequately in perceptual ability but have difficulties in integrating A and V information. The present study would appear to support such a notion. In either case, the skills necessary for efficient academic skills, i.e., reading and writing, are deficient. By not being able to make equivalences and associations between visual stimuli (letters) and their auditory equivalents (their associated verbal representation), the dyslexic is clearly at an educational disadvantage in learning to read.

> "Cross-modal perception is found in the reading process where the reader must integrate visual symbols with their auditory equivalences...Reading disorders are due to an inability to make such conversions within the neurosensory system. Thus, the child who cannot convert from the visual modality to the auditory modality is able to learn what letters look like, but he cannot associate these visual images with their sound equivalences. Conversely, the child who cannot convert from the auditory modality to the visual learns what letters sound like but cannot associate it with the visual form of the letters." (Learner, 1971, p. 127).

A question remains as to why VV performance of the perceptual function and VA of the integrative function of these tasks is demonstrably superior to AA and AV processing respectively. (See Graph I.) The child in his early schooling through later years is exposed to educational-linguistic material primarily via the visual mode. The V to A linguistic process appears to be one of developing visual representations and discrimination of letters while gradually breaking down their overlearned auditory verbal associated parts. Therefore, in learning letters and words the visual modality is employed and emphasized in educational setting. "Since our system is strongly oriented in the visual perceptual realm, the world of vision receives our greatest attention and vision becomes our primary sensory avenue to the brain and knowledge." (Wegner, 1971, p. 81). One can conclude, therefore, by using linguistic material, i.e., letters, the child is better acquainted with the specific visual representation which is the emphasized mode of education. The result would support the suggestion in that the VV condition appears to be the easiest, while in the integrative tasks having a V target facilitated performance in VA tasks (Drake, 1976).

A theory of learning deficiency should demarcate and account for at least two subpopulations of dyslexic subjects: those with perceptual difficulties and consequently, integration deficits - auditory - visual, motor, kinetic - (N.B., Orton's theoretical construct); and those with accurate and efficient perceptual systems, manifesting deficiencies in only higher order cognitive integration (N.B., Birch and Belmont's theoretical construct). The results of the present study indicate a further refinement of the components necessary for an applicable theoretical construct for RR. By supporting Myklebust's findings, it is important to distinguish and be aware of the existence of the possibility of these two subpopulations of retarded readers. Thus these studies, including the support rendered in the present investigation, move toward a more applicable and definitive theoretical construct for learning - as it relates to reading disabled children - in both the research and clinical aspects of education, psychology and medicine.

SUMMARY AND CONCLUSIONS

Results from the present investigation indicate that RR are significantly deficient in tasks requiring the integration and transformation of linguistic information from one modality to another; i.e., AVI, when compared with NR performance. These results support previous findings that implicate AVI deficiencies in RR. The explanation for this intersensory deficit appears to be complex. RR were also found to be significantly deficient in tasks requiring intrasensory processing, A and V. By utilizing a descriptive analysis it appears that intrasensory performance by RR could not fully account for the degree of variance observed in intersensory functions. Further research is needed to determine whether there exist two distinct subgroups of RR (as implicated in this study) - those with perceptual difficulties (therefore receiving information inaccurately, making effective integration impossible) and those who receive information accurately and demonstrate difficulty only when having to integrate across-modalities. Additionally, IQ, visual sequential, visual rotational, and auditory sequential perceptual memory were not significantly divergent from NR. Consequently, these do not appear to be intervening variables.

During the original focus on RR the primary interest was on visual (and visual motor) difficulties; more recently, however, researchers and educators alike have recognized the importance and contribution of auditory-articulation deficits in RR. The present results, using linguistic material and extensive controls support contemporary research's focus on AVI difficulties as a more generalized and universal deficit in RR. These abilities are directly related to the reading (and writing) process; V to A (and A to V) intersensory processes are requirements for such abilities. These results must be interpreted in light of demonstrable perceptual difficulty by a significant proportion of RR, thus supporting the notion of heterogeneity among RR perceptual and integrative abilities. One therefore is cautioned against single causative components of AVI deficiencies in RR.

The results and conclusions from this investigation (as well as recent trends in the literature) have important implications for AVI research, medicine, and particularly educational assessment and remediation.

IMPLICATIONS: Research

One might hypothesize that the growing body of contradictory results in the study of dyslexia is related to the heterogeneity of subject characteristics. If further research confirms the existence of two subgroups, one having perceptual deficits and the other having only integrative deficits, then general normative studies would be misleading in terms of causal characteristics. Researchers have developed to the point of experiencing general difficulties with RR, A, V or AVI. Extensive, in depth single or small group studies may provide more information than studying population samples.

Modification of, or, designs such as employed in the present investigation may provide necessary information on AVI and perceptual processing. One has access to an individual's performance, using linguistic stimuli, on intra-sensory processing abilities as well as information on inter-sensory processing A to V and V to A. A more detailed analysis of individual performance and information on subjective processing involved in combinations of A and V information may lead to a better understanding of RR, and possibly subgroups of intra and intersensory deficit readers.

Another form of AVI research which would be beneficial would be a longitudinal AVI study, again incorporating a similar design as the present investigation. A popular view of RR is stated in a maturational-developmental hypothesis which attributes RR to a reduction in developmental rate in acquiring the specific skills necessary for reading. One might hypothesize that RR children go through various stages of maturational development that are similar to NR but are delayed. They first go through a stage of difficulty in perceptual processing which recedes, leaving integration deficits. Whether a RR child demonstrates perceptual or only integrational deficiency may be a function of the developmental process and not a type of cognitive inability.

This design is also applicable to other types of stimuli which would be of value in understanding RR. Some of these might be more visually or auditorily confusing letters and sounds - e.g., phoneme-grapheme pairs or words, which may further discriminate those RR with perceptual or integrative difficulties. There is some evidence that RR have significant difficulties only when having to interpret and transform abstract linguistic intersensory information and do not have difficulty with more concrete picture stimuli (Critchely, 1973, pp. 59-60). Critchley contends that: "The difficulty concerns the inner structure of the word and its sounds." (p. 60). The possibility for modification and usefulness in investigating perceptual and integrative questions appears infinite, but more likely than not the most beneficial results will come from detailed analysis of individual modes of performance and abilities in each of A, V, and AVI processing.

IMPLICATIONS: Medicine

In the present state of medicine, neurologists no longer maintain that if positive neurological findings are not forthcoming, there is no neurological involvement. Rather, they are aware of the fact that their procedures and techniques do not reveal all dysfunctions of the brain.

> "Because there is not a 100 percent correlation between behavioral and neurological evidence, either is used to make the final classification...As diagnostic procedures are developed and improved, the number in whom neurological evidence is lacking will be reduced." (Myklebust, 1964, P. 24).

The present results demonstrate a lack or inability of RR to process AVI information (and in several cases these inabilities appear at a perceptual, A or V level) as effectively as NR. This inability would indicate the existence of a dysfunction in the neurological system of RR; however, it may remain discrete and inaccessible to neurological assessment. This might suggest that the dysfunction could be a maturational, or neurochemical involvement as opposed to a more permanent structural alteration.

Miller (1964) investigated the overloading of the neurological system. A dysfunction in the brain lowers the limit of tolerance for processing information. A child may be able to deal efficiently with intraneurosensory processing but "show symptoms of disintegration when intra-neurosensory and complex integrative functions are required ...information being received through a given sensory modality impedes integration of that being received through another." (p. 141). Thus a child may demonstrate symptoms of RR due to a lack of integrative capacity to process effectively AV transformation and thus lower the equivalency between symbols and their associated sounds. This symptomatology has been demonstrated in the present research. The neurological implication can only be of a global nature, in that higher order cognitive functions are involved. Implicated are two subgroups, both evidencing different levels of dysfunctioning; one at a perceptual level, the other only when integrative processes are demanded. Research results similar to the present would support a neurological deficit hypothesis and would encourage further refinement of neurological assessment.

As in the case with the present cognitive study, heterogeneity may be the cause of conflicting results in neurological assessment. Refinement of and appreciation for the need for individual research has become an inherent aspect of neurological as well as of cognitive and educational research. Any attempt on the part of researchers to identify specific, common neurological deficits will probably remain unsuccessful due to a lack of a single, common etiological factor.

IMPLICATIONS: Education

The most important implications rest with the field of education. Although this is not a suitable time or place for an extensive discussion, this research has its greatest implications for both educational assessment and remediation of RR children. Educators are infrequently aware of the importance of differentiating these two primary deficits. Demonstrable deficits in one area may mean emphasizing more appropriate remedial intervention strategies of the more common approach of that which is most effective most of the time.

In terms of assessment, there are reportedly no standardized tests available to educators to assess a child's deficiency in AVI processing (Wallace, 1975). There is, however, a multitude of assessment materials for uni-modal (intrasensory) assessment. But, as illustrated here, a child may perform adequately on such tasks and, not having demonstrable deficiencies on known assessment tools, he is likely to be classified with other than learning disabilities for his RR. However, the child's difficulty is evidenced only when integration of more than one modality is involved.

> "Little attention has been given to the assessment of intermodal perceptions. Chalfant and Scheffelin suggest that 'there is a need to develop standardized tests for multiple-stimulus integration...At the present time the only tests which are available are those which have been developed by researchers actively investigating the area.'" (Wallace, et al, 1975, p. 92).

Results from the present investigation illustrate the importance of assessing AVI in addition to perceptual abilities in RR. The author of the present investigation believes that modification of the present design and equipment could assess the child's ability to process A, V intramodalities as well as the important intersensory processing abilities A to V or V to A. The resulting information would be applicable to the reading problem because it is the only test (to the author's knowledge) which incorporates the Birch and Belmont (1964) type integration sequences, controls for known criticisms of this task, possesses intramodal controls, and deals exclusively with linguistic material. One could modify this task to include grapheme-phoneme combinations or use syllables or words as stimuli rated for age level. It may be, for example, that by using more confusable stimuli (both A and V) one may obtain a clearer distinction between perceptual and integrative deficits in RR. The possibilities are great, and by employing intra and intersensory linguistic tasks one obtains a complete assessment of the component skills necessary for reading. There are informal means of assessing A, V, AV and VA processing using nonstandardized procedures. For example, Hartstein (1971, p. 108) presents the following scheme:

> 1) Auditory-vocal. The sound is presented by the examiner, and the child responds with the name of the letter. [AA]
> 2) Auditory-motor. The sound of the letter is given, the child is asked to write the letter. [AV]
> 3) Visual-vocal. The letter is shown to the child, and he verbally gives the name of the letter and the sound associated with it. [VA]
> 4) Visual-motor. The child observes the letter and then writes it after it has been withdrawn from sight. [VV]

Emerging from the information on an individual's RR perceptual-integrative processing are several important questions regarding educational remediation. First, careful assessment of the intrasensory or intersensory deficits must be measured, because perceptual unimodal training techniques would not be the most effective for an RR with integration difficulties and vice versa.

There exists considerable variability among methods of instruction, particularly to the extent that the spoken word and its parts are associated with the printed word and its parts. Teachers, in their daily routine - and who may or may not be aware of the A to V or V to A integration process involved - characteristically point to letters, syllables, or words and say the sounds, syllables or words at a nonstandardized rate as the child scans the printed characters. Depending on the unit size of the linguistic chunk emphasized (letters or words), various degrees of demand are involved for the child's self-teaching. If larger unit sizes are used, greater self-teaching demands are placed on the child to develop for differentiation, organization and application of V to A associated matching.

> "The less emphasis given to the matching of sounds with letters, the greater can be the load on the A-articulatory system as the influx of many new words become similar in sound and articulatory production. Furthermore the load on the visual system increases as the child searches and scans for distinctive configurations among scores of letters or words." (Hartstein, 1971, p. 163).

An extensive review of teaching techniques is beyond the scope of this paper, but certain principles should be kept in the forefront of remediational goals.

First, small units of symbol sound associations should be used starting from intensive work on letters, then syllables and finally words. The result of the present investigation indicates AV and VA matching are particularly difficult; therefore, one might conjecture that learning and automatization would be particularly difficult too. By ensuring the minimum demand on the system (less confusion), VA letter to sound matching will be more effectively developed.

Second, multimodal techniques should be utilized. Approaches such as the Fernald (1943) which emphasize the integration of visual, auditory, kinesthetic and tactile (VAKT techniques); Gillingham-Stillman (1965) which emphasizes individual letters (by teaching letter sounds, visual symbols and various associations by tracing and copying particular letters that the child and tutor see, say and listen when a linguistic unit is involved). These two approaches have had significant success (Drake, 1972). It is interesting to note that Wagner, et al, (1971) describe and support utilization of exercises which strengthen one's ability to "translate A signals into V symbols and highly recommend Morse code type exercises similar to Birch and Belmont and Gregory and Gregory (1973) as educational material based on research.

Third, if perceptual difficulties (A or V) appear to be the major cause of integration difficulties, these techniques (by employing motor input) would benefit those with perceptual difficulties.

In summary, it has been demonstrated that RR have significant difficulty in making equivalence judgements between two sense modalities, A and V. These difficulties in some cases appear to be related to intrasensory deficits and in others are independent. Because of the strong similarity between this AVI task and reading (and writing), these results implicate a higher order deficit which may be responsible for reading retardation. These results, if supported by future investigations, will have important ramifications on the psychology of learning as related to RR, neurology, educational assessment and the development of remedial programs. This may prove to be one of the most valuable fields of study for potential investigations of individual RR Ss and their ability to process A, V, and AVI information. By utilizing linguistic materials, this design may be a model for vastly needed intra and intersensory assessment.

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NR: DATA

	S#	Gr.	VV	AA	VA	AV	Reading* Oral & Silent($\bar{x}$)	Spell.	Visual** Memory Sequential-Rotation Errors	DS	AGE	IQ
body	1	2.9	19	17	18	19	3.2	2.0	11-1	7	8-10	95
	2	2.9	20	18	18	17	3.1	3.2	15-6	9	8-0	91
	3	2.9	18	18	17	17	3.1	2.6	21-3	13	8-3	116
ton	4	2.9	18	18	18	17	3.2	3.1	12-2	10	7-10	104
	5	2.9	18	17	19	18	3.2	3.2	18-5	11	8-3	109
	6	2.9	19	17	17	15	3.3	3.4	20-2	10	7-8	100
	7	2.9	19	18	18	17	4.0	3.7	19-8	15	7-11	118
	8	2.9	19	17	16	17	3.0	3.9	21-3	7	8-7	115
	9	2.9	19	20	19	16	4.5	4.7	21-4	9	8-3	111
	10	2.9	19	20	18	19	3.2	3.2	17-4	11	8-9	103
body	11	3.9	18	19	16	15	4.0	4.7	13-5	11	8-2	113
	12	3.9	19	18	19	16	3.7	3.7	22-9	11	9-6	108
	13	3.9	19	18	16	19	4.5	4.7	18-9	11	8-10	104
ston	14	3.9	20	19	18	18	4.3	4.7	19-4	9	8-5	100
	15	3.9	19	18	19	17	4.8	3.9	26-8	11	8-10	105
	16	3.9	18	19	19	17	5.2	4.7	21-6	12	9-3	116
	17	3.9	19	18	19	17	4.6	4.7	21-8	9	8-7	106
	18	3.9	19	18	18	17	4.0	4.1	16-1	10	9-3	108
	19	3.9	18	19	20	20	4.8	3.9	19-7	13	8-3	133
	20	3.9	18	16	17	16	3.8	3.7	21-3	9	8-8	97
AN =			18.8	18.1	18.0	17.2	3.9	3.8	18.6-4.9	10.4	8.5	107.75

*Grade equivalence.

**The first number represents the score on the Visual Sequential Memory test (ITPA), and the second number represents the number of rotational errors made during this test.

RR: DATA

	S#	Gr.	VV	AA	VA	AV	Reading* Oral & Silent ($\bar{x}$)	Spell.*	Visual** Memory Sequential-Rotation Errors	DS	AGE	IQ Verbal
body	1	2.9	20	17	13	15	2.0	2.0	20-8	10	8-5	99
	2	2.9	15	19	16	14	1.6	.08	19-2	11	8-6	124
	3	2.9	15	18	16	12	1.7	1.4	17-3	11	8-5	110
	4	1.9	18	17	15	14	.03	.04	14.12	13	8-11	105
ston	5	2.9	14	13	16	12	.06	1.2	18-8	7	7-10	129
	6	2.9	18	18	17	16	1.5	1.8	28-5	11	8-6	116
	7	2.9	18	15	15	9	.08	.08	23-2	9	8-2	100
	8	2.9	16	17	16	13	1.4	.7	20-5	10	8-0	102
	9	2.9	18	17	15	15	1.1	1.2	16-3	10	7-9	108
mbridge	10	3.9	16	20	16	12	2.6	.07	12-5	9	9-2	104
	11	3.9	16	18	16	15	2.5	1.9	12-3	10	9-6	103
	12	3.9	17	14	13	14	2.8	1.9	19-16	8	9-1	106
	13	3.9	18	18	11	11	3.1	3.1	21-9	10	9-6	111
	14	3.9	18	19	15	13	2.9	2.9	20-4	11	8-10	114
	15	3.9	18	17	18	13	2.7	.05	20-12	12	9-4	108
	16	3.9	18	13	16	11	1.3	.03	23-2	6	9-4	103
	17	3.9	18	18	13	10	2.3	.09	19-5	12	9-6	104
abody	18	3.9	18	16	14	12	2.1	1.4	22-2	11	8-7	104
	19	3.9	15	17	16	16	2.5	1.4	13-3	13	8-6	113
ston	20	3.9	18	17	16	13	2.1	.02	21-8	9	9-1	115
AN =			17.1	16.7	15.2	13.0	1.8	1.1	19.2-6.1	10.2	8.8	109.75

*Grade equivalence

**The first number represents the score on the visual Sequential Memory test (ITPA), and the second number represents the number of rotational errors made during the test.

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WISC-R RECORD FORM

Wechsler Intelligence Scale for Children—Revised

NAME APPENDIX C AGE ____ SEX ____

ADDRESS ____________________

PARENT'S NAME ____________________

SCHOOL ____________________ GRADE ____

PLACE OF TESTING ____________________ TESTED BY ____

REFERRED BY ____________________

WISC-R PROFILE

nicians who wish to draw a profile should first transfer the child's *scaled scores* to the row of boxes low. Then mark an X on the dot corresponding to the scaled score for each test, and draw a line nnecting the X's.*

Scaled Score	VERBAL TESTS: Information	Similarities	Arithmetic	Vocabulary	Comprehension	Digit Span	Scaled Score	PERFORMANCE TESTS: Picture Completion	Picture Arrangement	Block Design	Object Assembly	Coding	Mazes	Scaled Score
Scaled Score	☐	☐	☐	☐	☐	☐	Scaled Score	☐	☐	☐	☐	☐	☐	Scaled Score
19	•	•	•	•	•	•	19	•	•	•	•	•	•	19
18	•	•	•	•	•	•	18	•	•	•	•	•	•	18
17	•	•	•	•	•	•	17	•	•	•	•	•	•	17
16	•	•	•	•	•	•	16	•	•	•	•	•	•	16
15	•	•	•	•	•	•	15	•	•	•	•	•	•	15
14	•	•	•	•	•	•	14	•	•	•	•	•	•	14
13	•	•	•	•	•	•	13	•	•	•	•	•	•	13
12	•	•	•	•	•	•	12	•	•	•	•	•	•	12
11	•	•	•	•	•	•	11	•	•	•	•	•	•	11
10	•	•	•	•	•	•	10	•	•	•	•	•	•	10
9	•	•	•	•	•	•	9	•	•	•	•	•	•	9
8	•	•	•	•	•	•	8	•	•	•	•	•	•	8
7	•	•	•	•	•	•	7	•	•	•	•	•	•	7
6	•	•	•	•	•	•	6	•	•	•	•	•	•	6
5	•	•	•	•	•	•	5	•	•	•	•	•	•	5
4	•	•	•	•	•	•	4	•	•	•	•	•	•	4
3	•	•	•	•	•	•	3	•	•	•	•	•	•	3
2	•	•	•	•	•	•	2	•	•	•	•	•	•	2
1	•	•	•	•	•	•	1	•	•	•	•	•	•	1

*See Chapter 4 in the manual for a discussion of the significance of differences between scores on the tests.

	Year	Month	Day
Date Tested	____	____	____
Date of Birth	____	____	____
Age	____	____	____

	Raw Score	Scaled Score
VERBAL TESTS		
Information	____	____
Similarities	____	____
Arithmetic	____	____
Vocabulary	____	____
Comprehension	____	____
(Digit Span)	(____)	(____)
Verbal Score		____
PERFORMANCE TESTS		
Picture Completion	____	____
Picture Arrangement	____	____
Block Design	____	____
Object Assembly	____	____
Coding	____	____
(Mazes)	(____)	(____)
Performance Score		____

	Scaled Score	IQ
Verbal Score	____*	____
Performance Score	____*	____
Full Scale Score	____	____

*Prorated from 4 tests, if necessary.

NOTES

DURRELL ORAL READING ________ GR.
SILENT READING ________ GR.

SLOSSON ORAL - SORT ________ GR.

STANFORD ACHIEVEMENT SPELL. ________ GR.

ITPA VIS. SEQ. MEM. ________ SC.

VV ______/15

AA ______/15

VA ______/15

AV ______/15

TOTAL ______ ERRORS

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