Reading Ability and Temporal Processing in the Auditory, Kinaesthetic and Visual Modalities

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Abstract

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The study investigated temporal processing in the auditory, kinaesthetic, and visual modalities in grade 4 boys. 12 poor and 12 good readers performed a spatial task in which they judged whether a spatial pattern was the same as a temporal pattern, and a temporal task in which they judged whether two consecutive temporal patterns were the same. The tasks were presented in an ABAB sequence over four test sessions. Each subject was given 10 patterns in each modality in each session. An analysis of variance showed no significant task effect, a significant reading group effect [$F(1,22) = 14.80$ $p < .005$], and a significant modality effect [$F(2,44) = 3.75$ $p < .05$] which was associated with a significant Group X Modality interaction [$F(2,44) = 3.22$ $p < .05$] and was attributable to the performance of the poor readers. Poor readers made fewer correct responses than good readers and unlike the good readers, performed worse in the visual, than in the auditory or kinaesthetic modalities. The results were interpreted as suggesting a temporal processing deficit in dyslexia. The deficit specific to the visual modality was attributed to faulty attention.

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Developmental dyslexia has been defined as a condition in which the child "is unable to learn to read with proper facility despite normal intelligence, intact senses, proper instruction, and normal motivation" (Eisenberg, 1962, P. 4). For reasons as yet undetermined the condition is more common in boys than in girls. Theories regarding the etiology of dyslexia have tended to be either biological or psychological in nature. Biological theories attribute dyslexia to such factors as "maturational lag", "a pattern of disturbed neurological organization", or "minimal brain dysfunction", while psychological theories deal with the child as a product of his experiences and attribute dyslexia to such factors as "incomplete resolution of internal and external conflicts". (Heinicke, 1972).

One promising research approach based on a biological theory was initiated by Birch and Belmont in 1964. Their assumption was that reading involves a match of an auditory input of spoken language to a spatial input of written language. They postulated that one of the causes of developmental dyslexia might be "a primary inadequacy in the ability to integrate auditory and visual stimuli". Their subjects were two groups of boys, good and poor readers, 9 to 10 years of age. In their study the experimenter tapped out a rhythm on a table edge with a pencil on each trial, and then asked the child to identify which one of three spatial dot patterns shown on a card matched the tap pattern he had just heard. Each dot pattern consisted of a row of dots separated by either short or long spaces representing the short or long time intervals in the tap patterns. Birch and Belmont found that retarded readers had significantly more difficulty than normal readers in performing this task. They interpreted their finding as indicating that auditory-visual integration is one of the several factors that contribute to reading disability.

Birch and Belmont (1965) subsequently administered their task to children in elementary school, and found that matching performance improved with age. The improvement was most rapid in the early grades and reached an asymptote by the fifth grade. In addition, significant positive correlations were found between IQ and reading performance for all grades except the fourth grade. A finding of greater importance, however, was that there were significant positive correlations between matching performance and reading performance for grades 1 and 2, although not for grades 3 to 6. For first graders, in fact, matching performance was more highly correlated with reading skill than was IQ, although for second graders, IQ was more highly correlated with reading performance that was matching performance. This study was interpreted by Birch and Belmont as indicating that intermodal integration is of importance at the time of acquisition of reading skills, but that the level of reading skill reached in later years is related to intellectual competence.

Zurif and Carson (1970) suggested that the poor performance of retarded readers on matching tasks of the Birch and Belmont type might be due not to poor auditory-visual integrative ability as Birch and Belmont claimed, but rather to an inability to process the temporal material in the auditory portion of the task. Thus in their study of good and poor readers selected from boys in grade 4, they introduced, in addition to a slightly modified version of the Birch-Belmont task, two intramodal temporal tasks: one auditory, and the other visual. The two intramodal tasks involved judging pairs of patterns as same or different, rather than selecting the correct match from three alternatives as in the standard Birch-Belmont task. The intramodal auditory task was the rhythm subtest of the Seashore Measures of Musical Talent battery. The visual temporal patterns were presented by means of a flashing light and were not the equivalent of those used on the auditory task. They found normal readers to be significantly superior to retarded readers on all three tasks. For good and poor readers combined, performance on all three tasks was significantly positively correlated. The correlations although significant were not very high, and since the groups were combined, might have been attributable to the performance of good readers only. The correlations suggest that a common factor, presumably temporal processing ability, but possibly simply an attentional or motivational factor, may be tapped by the three tasks. Performance on the three tasks could not be compared directly, however, since the patterns employed were not equivalent across tasks. Thus even if the general temporal processing deficit hypothesis is entertained, it is not possible from the data to determine whether the difficulty of poor readers on the Birch-Belmont task is solely attributable to misperception of temporal sequences or whether it reflects both faulty temporal processing and faulty cross-modal integration.

Bryden (1972) pointed out that the Birch-Belmont task involves a shift from temporal to spatial processing as well as a shift from one modality to another, and hence investigated temporal-spatial processing as a factor in the inferior performance of poor readers on the Birch-

Belmont task. He administered nine tasks to two good reader and two poor reader groups, one of boys and one of girls in each case, in the fourth grade. The task represented all possible combinations of three presentation modes paired: auditory, visual temporal, and visual spatial; and subjects were required to judge whether two patterns presented consecutively were the same or different. The same patterns were used for each task. They were presented spatially in the form of dot patterns like those used by Birch and Belmont, as a visual temporal sequence by means of ½-sec. light flashes, and as an auditory sequence by means of clicks produced by depressing a telegraph key manually. Four tasks were cross-modal and five were intramodal. Two of the cross-modal tasks and two of the intramodal tasks involved a shift from one presentation mode to the other, temporal to spatial. Three of the intramodal tasks required no shift of presentation mode. Bryden found that performance on the intramodal visual task in which both patterns were presented spatially was superior to performance on any of the other eight tasks, and that tasks requiring a temporal to spatial shift were more difficult. He also found a difference between cross-modal and intramodal tasks, with cross-modal tasks being more difficult. In addition, he reported that there was no difference between performance of the males and the females and that good readers were superior to poor readers in overall performance, although the differences were only significant for four tasks: auditory-auditory, visual temporal-auditory, visual temporal-visual spatial, visual spatial-visual temporal. The difference between groups was not significant for the condition equivalent to the standard Birch-Belmont task — the auditory-visual spatial task. A similar study (Sterritt, Martin, & Rudnick, 1971) was published at approximately the same time as the

Bryden study. Although Sterritt et al. presented the same nine tasks, their sample, a group of potential poor readers who had completed a headstart programme and were about to enter Grade 1, was atypical. Moreover, they used a between-subjects design which might not be sensitive to slight cross-modal differences. They did not in fact find a difference between cross-modal and intramodal tasks. Nevertheless, Sterritt et al. obtained two findings which were also obtained by Bryden: that performance on the pairs in which both patterns were presented spatially was superior to performance on any of the other eight tasks, and that patterns involving temporal to spatial integration were most difficult. Bryden suggested that the difficulty experienced by poor readers on the Birch-Belmont task neither results from an auditory-visual integration problem, nor a general temporal processing deficit, since his sample of poor readers showed equivalent deficits on all tasks. He preferred to accept Blank and Bridger's (1966) notion that poor readers have difficulty in converting the temporal sequences into a verbal code. This verbal coding deficit he suggested is related to a general language deficit.

A different approach to the nature of the poor reader's deficit on the Birch-Belmont task has been used by Taylor and her students. They have attempted to rule out the general temporal processing deficit hypothesis by investigating temporal processing in the kinaesthetic modality. They pointed out that there is some evidence both for the existence of a separate primitive enactive representation system or "motor memory" (Bruner, 1964) which is the first to appear developmentally and continues to coexist with the iconic and symbolic systems which develop later; and also that there is some evidence which points to the existence of such a system in dyslexics. For example, it is known that involving the dyslexic's kinaesthetic sense, by having him trace large letters in the air, or his sense of touch, by tracing letters on his back, may help him learn to discriminate between two readily confused letters. Accordingly they hypothesized that the poor reader's deficit on the Birch-Belmont task might well disappear if the temporal patterns were presented in the kinaesthetic modality. Hence Taylor and Carson (1969) presented three spatial matching tasks of the Birch-Belmont type. In addition to the auditory rhythms of the standard Birch-Belmont task, their subjects were given a task in which they had to match kinaesthetic temporal patterns, and also a task in which the temporal patterns to be matched were presented simultaneously in the kinaesthetic and auditory modalities. To present the kinaesthetic stimuli, patterns were tapped into the child's left palm by the experimenter who held the subject's right hand around a pencil and moved it up and down to tap out the rhythms. The subjects were two groups of lower socioeconomic class boys, good and poor readers, in the fourth grade. Taylor and Carson found that while performance on the two conditions involving kinaesthetic temporal input did not differ and was superior to that on the standard Birch-Belmont task which involved only auditory input, good readers were still superior to poor readers on all three tasks. A significant interaction between reading group and task, however, reflected the fact that there was a greater improvement in the poor readers' performance when stimuli were presented in the kinaesthetic modality. Thus the results did not disprove the hypothesis of a general temporal processing deficit in dyslexia. Since both groups matched kinaesthetic temporal sequences more easily, it was suggested that either heightened attention or enhanced perception in the kinaesthetic modality might have accounted for the greater effectiveness of the kinaesthetic mode of presentation.

Taylor and Polster (1972) investigated whether the greater effectiveness of the kinaesthetic presentation of temporal patterns was attributable merely to increased attention because the child was engaged in a motor activity, or whether it was in fact the result of kinaesthetic stimuli being more efficiently processed. In one condition, the standard Birch-Belmont task was presented with an additional requirement that the child, while listening to the auditory patterns, simultaneously engage in a motor activity — twirling an eraser on the end of a string — which did not involve any reinforcement of the temporal patterns, but did involve as much arm movement as the Taylor-Carson kinaesthetic task. The standard Birch-Belmont task and the Taylor-Carson kinaesthetic task were presented as control conditions. The subjects were middle class boys, good and poor readers, in the fourth grade. Good readers were found to perform better than poor readers on all three tasks, and matching performance was again found to be better for temporal patterns administered via the kinaesthetic modality than for those administered via the auditory modality. Scores on the task in which the child engaged in irrelevant motor activity while listening to the auditory patterns were intermediate to those for the other two tasks, but the difference was not significant in either case. Thus increased attention could neither be confirmed nor ruled out as the factor accounting for the superiority of the kinaesthetic presentation.

The purpose of the present study was to investigate further temporal processing in dyslexic boys — more specifically to investigate temporal processing in the kinaesthetic modality within the context of the Birch-Belmont task. Accordingly, subjects were required to perform a spatial matching task of the Birch-Belmont type in three modalities. A Birch-Belmont auditory spatial matching task and its kinaesthetic equivalent were presented in an attempt to replicate the Taylor and Carson (1969) and Taylor and Polster (1972) findings that performance in the kinaesthetic modality was superior. Since the auditory and kinaesthetic tasks involved cross-modal as well as temporal to spatial integration a visual equivalent of the Birch-Belmont task was also included as a control to assess the role of temporal to spatial integration. In addition, subjects were required to perform an intramodal temporal matching task in the three modalities in order to permit comparisons of temporal processing ability in each modality, and also to permit assessment of the role of cross-modal integration through comparisons with the appropriate spatial matching task. Past studies have differed in that some (Zurif & Carson, 1970; Bryden, 1972; Sterritt et al., 1971) have used a same-different judgement task and others have used a matching-to-sample task (Birch & Belmont, 1964, 1965; Zurif & Carson, 1970; Taylor and Carson, 1969; Taylor & Polster, 1972). The matching task by placing a load on memory introduces an additional variable; therefore a same-different judgement task was used in the present study.

Method

Subjects

The subjects were 24 right handed males with no uncorrected visual problems and no known hearing problems, who were selected from good and poor readers in the fourth grade. The children came from five different schools in a middle class school district in the Montreal area. The 12 boys in the poor reader group had been classified by the schools as poor readers and placed in special education programmes. Reading level was assessed by the reading subtest of the Canadian Test of Basic Skills (CTBS) which had been routinely administered to all children by four of the schools and to all but poor readers by the fifth. The CTBS reading subtest was administered individually to poor readers in the fifth school for the purpose of the study. Each good reader was selected from boys whose CTBS scores indicated that they were reading at grade level or better on the basis of an IQ score that matched that of a poor reader within four points. For the poor readers scores on the Wechsler Intelligence Scale for Children (WISC) which had already been administered by the schools were used. IQ scores were obtained for the good readers by administering the Henmon-Nelson Group Test of Mental Abilities for grades three through six. Correlated t-tests indicated that the two groups as finally constituted did not differ significantly in age, but that the good readers while significantly inferior in IQ, were significantly superior in reading ability. The significant difference in IQ arose from a slight but consistent bias in the matching which was unavoidable because of the scarcity of good readers within the IQ range of the poor reader group. It was considered acceptable because the difference favored the poor reader group and the intention of the matching was to ensure that the good readers did not represent simply a highly intelligent group of children. The characteristics of the groups and results of the t-tests are presented in Table 1.

Test Patterns and Stimuli

The temporal patterns consisted of four to seven stimulus elements. The duration of each element was ½-sec., with a ½-sec. interval between elements and a 1-sec. interval between groups of elements. Three lists of 10 patterns each were used. Eight of the patterns in each list were taken from the Taylor and Carson (1969) study. The remaining patterns were constructed to be as complex as the most complex in the Taylor and Carson list. Each pattern was then randomly assigned a position within a list. Five patterns were then randomly selected within each list and each was paired with itself. The remaining five patterns were paired with different ones. Those patterns taken from Taylor and Carson were each matched with one of the two incorrect choices from their list. For the others, patterns were constructed which were similar in number of elements, but different in the way in which the elements were grouped. This produced three blocks of pairs of patterns, each containing five pairs of identical patterns and five pairs of different patterns. In addition, there was a block of three practice pattern pairs. The first pattern of the first, second, and third practice pairs consisted of three, four, and five elements respectively, in two or three groups of one to three elements. The second pattern in the first case differed in number, in the second case it was identical and in the third it was identical in number of elements but differed in rhythm. This practice block was used with each of the three blocks of test pairs. The

Table 1

Age, IQ, and Reading Level Characteristics of Good and Poor Reader Groups

Characteristics	Reading Group: Good Readers	Poor Readers	t
Age in months			
Range	116 - 128	116 - 129	
Mean	123	122	.13
IQ	Henmon-Nelson	WISC	
Range	98 - 113	101 - 112	
Mean	104.8	107.4	5.73*
CTBS Reading Grade Level			
Range	4.5 - 5.5	2.3 - 3.4	
Mean	4.8	2.9	15.83*
N	12	12	

*$p < .001$

experimental and practice patterns are shown in Appendix A.

Each block of pattern pairs with the three practice pairs was recorded on a separate Sony C-90 cassette tape. One side of each cassette contained both patterns to a pair, while a second side of the cassette contained only the first pattern of each pair and the time interval required by the second pattern of each pair. The two members of each pair were separated by a 3-sec. interval and the pairs were separated by 10-sec. intervals. The auditory stimulus was a 1000 Hz, 60 db tone. A Grason-Stadler noise generator, model 901 B, was used to produce the signal.

A set of 33 cards was constructed for use in the spatial task. Each of the second members of the pairs of the experimental and practice patterns was reproduced schematically on a separate 3-in. X 5-in. card. The elements of a pattern were represented by a row of ½-in. black dots with the short and long temporal intervals being represented by spaces between dots of 1/16-in. and ½-in. respectively. Appendix B shows a sample spatial stimulus card.

Apparatus

A Sony TC-124 tape recorder was used to play cassette tapes through its own speaker, through Clasonic headphones, model MD 802 B, and through a light system. The light system consisted of a 6-volt, No. SL 328, green pilot lamp mounted on a 3-in. X 4-in. X 5-in. Hammond Handy Case. The lamp was driven by a two-transistor amplifier located in the box. Power was supplied to the system by a Mallory M 918, 6-volt battery. A coaxial phono cable connected to the right extension speaker output jack of the tape recorder supplied the input signal to the light system.

Design and Procedure

Each child was tested individually in four test sessions separated by intervals of at least 10 days. The two matching tasks were administered in an ABAB sequence so that the third and fourth sessions were essentially replications of the first and second sessions. In the first and third sessions the subject was given the spatial task in which he was required to judge whether or not a spatial dot pattern was the same as a temporal pattern he had just experienced, while in the second and fourth sessions he was given the temporal task in which he simply had to judge whether or not two temporal patterns presented consecutively were the same. In each test session the subject was given all 30 patterns with a different 10-pattern block being presented in each of three modalities: auditory, kinaesthetic, and visual. The experimenter was seated across from the subject for the auditory and kinaesthetic conditions and beside him for the visual condition. Patterns were presented in the auditory modality by playing the appropriate cassette through the speaker of the taperecorder. In order to present patterns in the kinaesthetic modality the speaker of the taperecorder was disconnected and the experimenter listened to the tape through the headphones while simultaneously tapping the patterns into the subject's right palm by moving the child's left hand up and down as it grasped a pencil. Temporal patterns were presented visually in the form of light flashes by playing a tape with the appropriate patterns through the light system of the taperecorder with the speaker disconnected.

Four subjects within each group were assigned to one of three test orders in accordance with a complex Graeco-Latin Square design in which the orders of presentation of modalities and of blocks of patterns were independently counterbalanced. Each child was given the same order for sessions one and two, then given a new order for sessions three and four.

During testing, the child was seated at a small desk in a quiet room. For sessions during which he was presented with the spatial task, he was told he was going to see, hear, or feel a pattern, depending upon the modality, and that he was going to be shown an array of dots and he was to say whether the dot pattern was the "same" or "different". For the temporal task, the child was given the same instructions as for the spatial task, except that he was told he would see, hear, or feel two patterns and that he was to tell the experimenter whether they were the same or different. The instructions and the practice pairs were repeated for each block of patterns. For the practice pair only, the child was told whether each response was correct or incorrect. If the response was incorrect, he was given an explanation of his error and the pair was repeated until he appeared to recognize why his response had been wrong. The spatial patterns were presented three seconds after termination of the temporal pattern and the spatial card was removed as soon as the child responded. Time between blocks of patterns administered in different modalities was only the time that was necessary to change equipment. Each session lasted from twenty to twenty-five minutes. The results of the two sessions for each task were combined to obtain a score for each modality, a score being the number of correct responses out of 20.

Results

Table 2 presents the mean number of correct spatial and temporal judgements made by each group for each modality. A one-between two-within factor design was performed on the scores with modality and task as within-subjects factors and reading group as the between-subjects factor. Scheffé's multiple comparison procedure was used to test differences between means following significant main effects and interactions. The analysis of variance source table is shown in Table 3. The main effect of reading group was significant [$F (1,22) = 14.80$ $p < .005$]. Good readers performed significantly better than poor readers, making an average of 14.65 correct matches for both tasks and all three modalities combined, in contrast to a mean of 12.04 for the poor readers. There was no significant main effect of task. The poor readers, however, tended to make fewer correct temporal ($\overline{X} = 11.36$) than spatial matches ($\overline{X} = 12.72$), while the good readers performed equally well on both tasks (temporal $\overline{X} = 14.75$, spatial $\overline{X} = 14.55$). These data were reflected in the sizeable Group X Task interaction which just failed to reach significance [$F (1,22) = 4.24$; F of 4.30 required for $p < .05$].

The analysis showed that performance in the three modalities differed significantly [$F (2,44) = 3.75$ $p < .05$]. The mean scores for the combined reading groups were 13.66 for the auditory modality, 13.79 for the kinaesthetic modality, and 12.60 for the visual modality. Sheffé tests showed that performance in both the kinaesthetic and the auditory modalities was superior to that in the visual modality, although the difference was only significant at the .10 level, and that there was no significant difference between performance in the auditory and kinaesthetic modalities. In addition, there was a significant interaction between reading group

Table 2

Mean Number of Correct Spatial and Temporal Judgements Made by Good and Poor Readers in Each Modality

	Modality		
	Auditory	Kinaesthetic	Visual
Spatial Task			
Poor Readers	13.91	12.25	12.00
Good Readers	14.58	14.83	14.25
Temporal Task			
Poor Readers	12.08	12.50	9.50
Good Readers	14.08	15.50	14.67

Table 3

Analysis of Variance of Judgement Scores as a Function of Reading Group, Task, and Modality

Source	df	MS	F
Between subjects	23		
Reading group	1	245.45	14.80**
Error	22	16.58	
Within subjects	120		
Task	1	12.25	2.38
Modality	2	20.01	3.75*
Group X Task	1	21.77	4.24
Group X Modality	2	17.21	3.22*
Task X Modality	2	9.81	2.03
Group X Task X Modality	2	4.80	.99
$Error_1$	22	5.14	
$Error_2$	44	5.34	
$Error_3$	44	4.84	

* $p < .05$
** $p < .005$

and modality [$F(2,44) = 3.22$ $p < .05$], which is shown in Figure 1. The interaction reflected the fact that the significant difference between the auditory and visual modalities was attributable to the performance of the poor readers alone. The good readers although they scored highest on the kinaesthetic patterns did not, in fact, differ significantly in performance in the three modalities. On the other hand, the poor readers performed significantly worse in the visual modality than in the auditory modality ($p < .05$), although their performance in the kinaesthetic modality did not differ from that in either the visual or the auditory modality. The interaction also reflected the fact that the difference between the performance of good and poor readers was substantially greater when temporal patterns were presented in the kinaesthetic ($p < .005$) and the visual ($p < .001$) modalities, than when they were presented via the auditory modality ($p > .05$).

There was no significant triple interaction. In order to permit comparison of the results with those obtained by other researchers, however, the performance of the two reading groups in each modality was compared separately for the spatial and temporal tasks by means of two-tailed t-tests for correlated data. Although the scores of the poor readers on the spatial task were consistently lower than those of the good readers, the difference was significant by a two-tailed test only in the case of the visual modality ($t = 2.37$ $df = 11$ $p < .05$). The difference was marginally significant in the kinaesthetic modality ($t = 1.93$ $df = 11$ $p < .10$) and clearly not significant in the auditory modality, the task equivalent to the Birch-Belmont ($t = 1.65$). On the

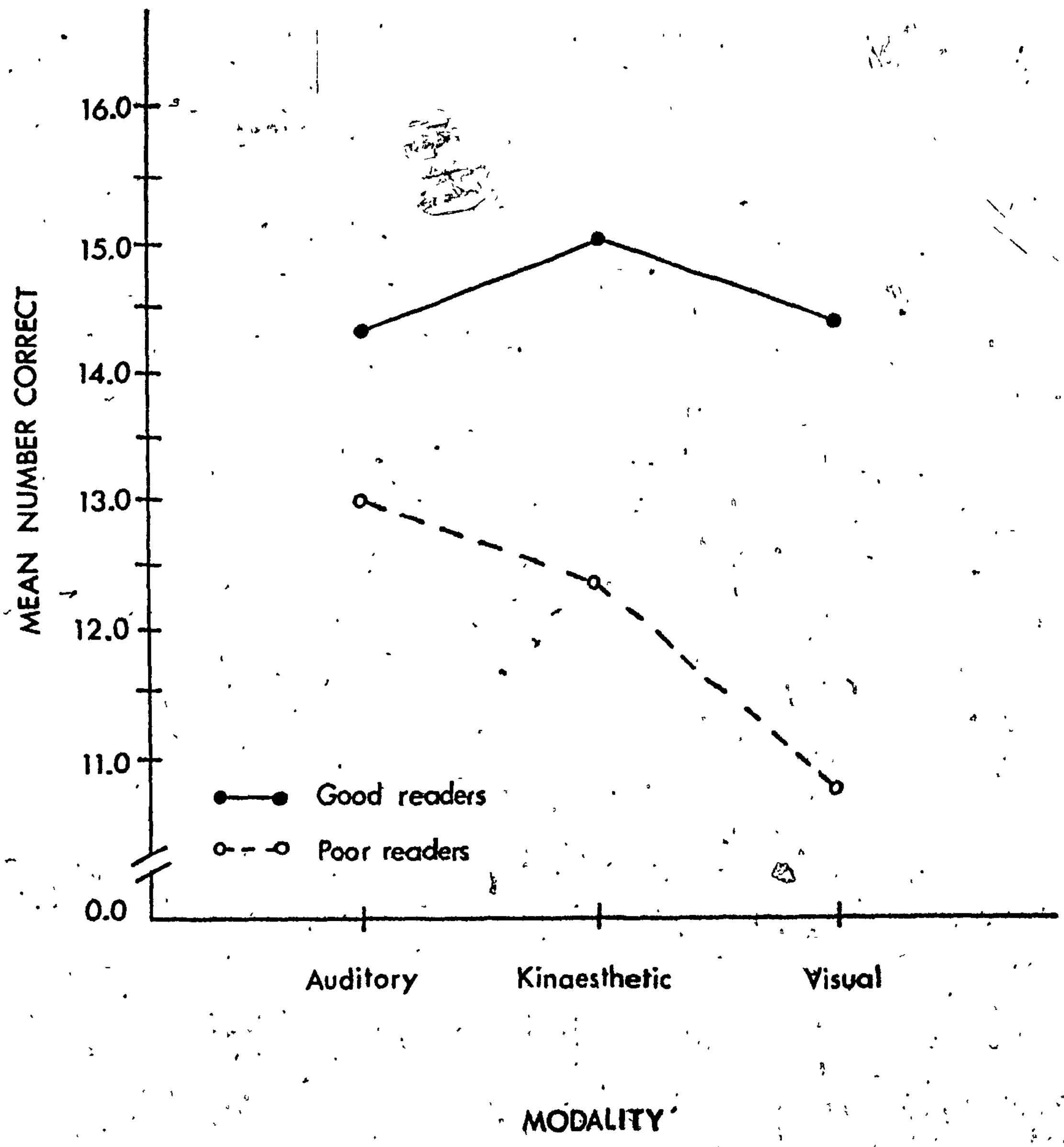

Fig. 1. Group X Modality Interaction.

other hand, the difference between the groups on the temporal task was significant for all modalities: auditory ($t = 2.44$ $df = 11$ $p < .05$); kinaesthetic ($t = 3.13$ $df = 11$ $p < .01$); and visual ($t = 6.63$ $df = 11$ $p < .001$).

Two stimulus pairs in block 1, two in block 2, and three in block 3 differed in both number of elements and rhythm. The proportion of correct judgements for the combined groups increased from .61 on the unconfounded stimulus pairs to .76 on the confounded stimulus pairs. Both good and poor readers showed improvement in performance on the confounded stimulus pairs. The proportion correct for the good readers increased from .70 to .84, while the proportion for the poor readers increased from .58 to .65. For both types of stimulus pairs, however, the proportion of correct judgements attributable to the poor reader group was .45 and the proportion of correct judgements attributable to the good reader group was .55. The mean number of correct judgements for the 23 unconfounded stimulus pairs was 16.15 for the good readers and 13.29 for the poor readers, while the mean number of correct judgements for the seven confounded stimulus pairs was 5.87 for the good readers and 4.77 for the poor readers. Correlated two-tailed t-tests indicated that good readers were significantly superior to poor readers on matching both the unconfounded stimulus pairs ($t = 3.34$ $df = 11$ $p < .01$) and the confounded stimulus pairs ($t = 2.42$ $df = 11$ $p < .05$).

Discussion

While performance in the kinaesthetic modality was marginally superior to that in the visual modality, the study failed to replicate the Taylor and Carson (1969) and Taylor and Polster (1972) finding that performance in the kinaesthetic modality for both good and retarded readers was superior to that in the auditory modality. The mean scores for the combined groups for the kinaesthetic and auditory modalities were, in fact, virtually identical. One explanation for this failure to replicate might be that while the experimenters in the Taylor and Carson and Taylor and Polster studies were males, the experimenter in the present study was a female. Since the kinaesthetic task required that the experimenter hold the subject's hands, it is possible that the boys in the present study might have been a little flustered or embarrassed.

The present study replicated the finding of a number of studies (e.g., Zurif & Carson, 1970; Bryden, 1972; Taylor & Carson, 1969; Taylor & Polster, 1972) that poor readers show a general deficit in performance when given the Birch-Belmont task in combination with either intramodal tasks or other cross-modal tasks. Both Bryden (1972) and the present study, however, found that the equivalent of the Birch-Belmont task, the spatial task in the auditory modality, failed to yield a significant difference between good and poor readers when tested in isolation, although the performance of the poor readers was slightly worse than that of the good readers in each case. Bryden's subjects like those in the present study were required to make a same-different judgement rather that match to sample. Perhaps these two methods of presenting tasks of the Birch-Belmont type are not equivalent, at least for poor readers. The question cannot be resolved until a study is conducted in which the two methods of presentation are compared.

Performance in the visual modality was worse than that in the kinaesthetic or auditory modalities. This effect was primarily attributable to the performance of the poor readers. The inferior performance of the poor readers in the visual modality cannot be attributed to a cross-modal integration problem since there was no cross-modal integration requirement in either task in the visual modality. Moreover, it cannot be attributed to a temporal-spatial integration problem since they performed worse on the visual temporal task (in fact only at chance level), than on the visual spatial task. In addition, verbal coding cannot be the primary factor in the deficit specific to the visual modality, since an inability to encode temporal patterns should affect all modalities equally. The one hypothesis that cannot be ruled out is that the deficit was related to inattention. The patterns presented in the visual modality required that the subject focus upon the light; any straying of his attention would mean loss of elements of the pattern being presented. Many poor readers, in fact, complained that the patterns presented in the visual modality were difficult, and that they didn't like the tasks because it was tiring to look at the light continuously. Thus it is reasonable to assume that their poor performance on both tasks in the visual modality reflected a failure to maintain concentration. Their chance level performance on the visual temporal task apparently meant that focussing attention upon the light for the longer length of time required to present two visual sequences was almost impossible for the poor readers.

There was no significant difference between performance on the spatial and temporal tasks for the combined groups, although the mean scores of the poor readers indicated that they performed worse on the temporal task in each modality. The contribution of the seven confounded stimulus pairs to the sizable Group X Task interaction is unknown, but the fact that an almost significant Group X Task interaction was obtained with the relatively small sample used suggests that an effect might well exist and might be significant in a larger sample tested with stimulus pairs that differ only in rhythm and not in number of elements. If this were so, it would provide evidence of a deficit in temporal perception in dyslexia.

Vande Voort, Senf, and Benton (1972) have suggested that the poor reader's deficit on the Birch-Belmont task is related to a defect in attention and/or a deficiency in the encoding processes where complex stimulus configurations are involved. The results do not eliminate the possibility of a verbal coding problem as a factor in the general deficit, since the impression of the experimenter was that the poor readers who performed worst attempted to code the stimuli, but their coding was inappropriate and inaccurate. For example, some of them attempted to count the elements in the stimulus without regard for the rhythm and erred on identical pairs arguing that they were different in number. Thus these children seemed unaware of the rhythm, despite their repeated experience with the practice pairs. The role of the confounded stimulus pairs in producing this behaviour is hard to determine. Both groups did better on the confounded stimulus pairs presumably because it was easier to detect that the pairs were different. The fact that errors were made on the confounded stimulus pairs indicates that subjects did not adopt a general counting strategy. Thus the fact that the proportion of correct judgements attributable to the poor readers was constant for both unconfounded and confounded stimulus pairs seems best interpreted as indicating that their deficit in performance relative to the good readers was accounted for by a failure to apprehend rhythm - the one factor common to both the unconfounded and confounded stimulus pairs. The possibility still remains then that the primary deficit detected by the Birch-Belmont task is one related to the perception of temporal sequences. This notion is supported by the existence of an almost significant Group X Task interaction, and the consistent and marked inferiority of the poor readers on the temporal task in all modalities. If language is seen as being represented by structure and patterns, a temporal processing deficit may well be associated with a general language deficite. Zurif and Carson (1970) suggested that although a subtle temporal processing deficit may not alter the speech of dyslexics, it may affect reading ability by preventing the formation of spelling-to sound correspondences.

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Appendix A

Schematic Representation of Experimental and Practice Pattern Blocks

Practice Pattern Pairs

	First Stimulus	Second Stimulus
1.	0 00	0 0
2.	00 0 0	00 0 0
3.	0 0 000	0 0000

Block 1

	First Stimulus	Second Stimulus
1.	00 00	00 00
2.	000 000	0000 00
3.	000 0 000	000 000 00
4.	00 00 00	00 00 00
5.	0 00 00	00 0 00
6.	000 0000	000 000
7.	0 00 0	0 00 0
8.	00 000 0	00 000 0
9.	0 00 0000	00 00 000
10.	000 00	000 00

Block 2

	First Stimulus	Second Stimulus
1.	00 000	0 000
2.	00 0 000	00 0 000
3.	0 0000 00	0 0000 00
4.	00 0 00	0 00 0
5.	0000 0 00	0000 0 00
6.	000 00 0	0 000 00
7.	00 00000	00 00000
8.	0 000	000 0
9.	00 0000	00 0000
10.	0 000 0	00 00 0

Block 3

	First Stimulus	Second Stimulus
1.	00 000 00	00 0 00
2.	0000 0	0000 0
3.	0 00000	00 000
4.	000 0	000 0
5.	000 0 00	000 0 00
6.	0 000 00	00 000 0
7.	00 00 0	00 00 0
8.	0000 000	000 000 0
9.	00 0000 0	00 000
10.	0 0 00	0 0 00

Appendix B

Sample Visual Dot Pattern Card