Is It Lateralization, Processing Strategies, or Both That Distinguishes Good and Poor Readers?

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Two experiments were conducted to determine whether poor readers eventually establish a dichotic right ear advantage as predicted by a maturational lag theory. The results of Experiment I revealed an ear asymmetry effect for normal subjects on all stimulus types. The asymmetry in the poor readers depended on age and stimulus type. The findings of Experiment II which required subjects to use a serial order of report showed that the use of recall strategies probably represents a significant factor in determining the size of the ear asymmetry. Results of both experiments were discussed in relation to existing theories.

Normal right-handed adults generally exhibit better recall of material presented to the right ear in a recall task in which different verbal items are presented simultaneously, one item to each ear (Broadbent & Gregory, 1964). On the other hand, this task, called a dichotic listening task, gives rise to a left ear advantage when subjects are asked to recall nonverbal material such as melodies or environmental sounds (Kimura, 1967).

While there is some agreement regarding the performance of adults on this task, the results of studies with children have not always been so straightforward. Some earlier studies supported the ideas of Lenneberg (1967) that cerebral dominance developed gradually and did not reach full maturity until after puberty (cf. Bryden, 1970; Satz, Bakker, Teunissen, Goebel, & Van der Vlugt, 1975). However, other studies, most notably those of Berlin and colleagues (Berlin, Hughes, Lowe-Bell, & Berlin, 1973) have shown a right ear advantage in the dichotic listening task in children as young as 5 years of age. Further, studies by Kinsbourne and his colleagues (Kinsbourne & Hiscock, 1977; Hiscock & Kinsbourne, 1978) have demonstrated lateralization of the speech centers in subjects as young as 3 years of age using a dual task procedure.

A related controversy, directly descended from views put forth by

Orton (1928, 1966), is whether children who are classified as poor readers are delayed in the lateralization of their speech centers when compared to normal children. For example, Satz and Sparrow (1970) and Satz and Van Nostrand (1973) proposed what has been called the maturational lag hypothesis which argues that reading-disabled children acquire certain cognitive functions later than do children who have normal reading skills. Germane to the present research is the argument that reading-disabled children are delayed in the lateralization of speech functions even more than are normal children. Of course, this theory predicts that while very young normal and poor readers might not differ in their performance on dichotic listening tasks, with neither showing much of an advantage for the right ear material, normal children of pubertal age would have developed lateralization to the point of giving the same right ear advantage as adults while poor readers of this age should continue to show a smaller or no right ear advantage. Further, by mid to late teens even the reading disabled subject would be assumed to have attained full speech lateralization and should show a normal adult right ear advantage in the dichotic listening task.

While these predictions appear to be fairly straightforward, the research directed at them has led to conflicting results and Satz himself (Satz, 1977) has argued that there is not solid support for this theory from the research using the dichotic listening task. For example, a few studies have reported a developmental increase in the right ear advantage with normal children (Satz et al., 1975) and either no right ear advantage (Zurif & Carson, 1970; Witelson & Rabinovitch, 1971) or a delayed right ear advantage in reading disabled children (Satz, Rardin, & Ross, 1971). On the other hand, Berlin et al. (1973) and Sobotka (1974) reported a right ear advantage in the recall of dichotically presented items for normal and poor readers as young as seven.

This latter work has given rise to a theory proposed by Porter and Berlin (1975) in which it is argued that the lateralization of auditory and phonetic processes which determine the ear asymmetry effect occurs early in life, probably by the age of 5. This theory attributes the enhanced right ear advantage of older children as reported by some investigators (i.e., Satz et al., 1975) to more slowly developing mnemonic processes unrelated to maturation of the nervous system. In sum, this theory predicts a right ear advantage for all subjects by age 5 and attributes any increase in right ear advantage for older children to their enhanced ability to process and recall more items from memory.

The discrepant findings of Berlin et al. (1973) and the studies from Satz' lab (Satz et al., 1971, 1975) have served to generate a great deal of research and discussion but it is very difficult to compare their results because of task differences. Whereas Satz et al. (1975) used Dutch numerals to Dutch subjects, Berlin et al. (1973) used computer-generated

CV syllables with the same final vowel that were phonetically very similar. The problem of trying to compare across studies using different stimuli is probably common to all human cognitive tasks. Words, digits, CV syllables, and environmental sounds vary along many dimensions from each other such as meaningfulness, acoustic properties and temporal duration. But, probably of even more importance is the fact that the variability of these dimensions is not equivalent for the different classes of stimuli. For example, while CV syllables differ little in meaning and acoustic properties, words differ greatly on both dimensions. These two variables, along with others (many probably unknown), could have an effect on performance in the dichotic listening task even if different variables influence different cognitive processes. It is impossible to control for all the conceivable differences in classes of stimuli but it is possible to use the different stimuli in the same procedure and compare patterns of performance. That is one of the major goals of the present research.

Finally, some researchers (Bryden, 1963; Inglis, 1960) have suggested that the adoption of a recall strategy which involves consistently recalling items delivered to the right ear first is a primary cause of the right ear advantage typically found in normal adults. These authors have argued that, since material recalled second in sequence (i.e., from the left ear) is subject to more output interference and more decay from time spent in storage, higher recall performance should occur for that material which is reported first. In a study relevant to this issue, Malatesha (1976) showed that, with computer-generated CV syllables as stimuli, there was a developmental increase in the tendency of reading-disabled children to recall stimuli from the right ear first.

Thus, a study needs to be conducted comparing recall performance of normal and poor readers when the order of reporting (i.e., by left and right ears) is controlled. It could then be determined whether differences in performance on dichotic listening tasks between good and poor readers resulted from differences in hemispheric laterality or differences between early and late recall of material.

Two experiments were conducted to address these issues. Both experiments were cross-sectional developmental studies comparing normal and poor readers ranging in age from 7 to 15 years on the recall of dichotically presented lists of verbal items. The items were words, digits, and CV syllables, all computer generated. The first experiment was performed to investigate developmental differences in the dichotic listening task for normal and poor readers when the order of reporting different items presented simultaneously to the two ears is unconstrained. The second experiment controlled for order-of-reporting strategies by specifying the ear to be recalled from first and, consequently, the one to be recalled from second.

EXPERIMENT I

This experiment will allow us to test the prediction from the theory proposed by Satz and Sparrow (1970) and Satz and Van Nostrand (1973) that, while both normal and poor readers will ultimately show a right ear advantage in the dichotic listening task, the poor readers will show this asymmetry at a later age than will the normal readers. We should also expect that both groups would fail to show a right ear advantage at the youngest ages tested here. The use of a range of stimuli further permits greater generalization than has been allowed from previous studies.

Method

Subjects. Seventy male subjects participated in the study. One group was composed of 34 children identified as poor readers and was composed of children from three age groups: ten 7-year-olds (6–8), twelve 11-year-olds (10–12), and twelve 15-year-olds (14–16). Thirty-six normal readers drawn from similar age groups and with equal proportions of black and white children as the poor reader group served as a control group. Thus, there were 12 boys at each age in this group.

Poor readers were identified as children who manifested a severe reading deficiency in spite of being of normal intelligence. Reading retardation was defined for the youngest poor readers as scoring at least one-half to two grade levels below the expected level of reading achievement as measured by the Wide Range Achievement Test (WRAT) and for the older poor readers as greater than two grade levels below the expected level. Normal readers were defined as children who were reading at the expected grade level or above. Level of intellectual functioning was assessed for each subject with the Performance scale of the WISC-R (PIQ) as the measure of intelligence. Children whose PIQ did not fall within the average range of intelligence (IQ > 91) were excluded from the study. Table 1 shows the means and standard deviations for the WRAT and PIQ scores for all six groups of children.

An analysis of variance performed on the PIQ scores of normal and poor readers showed no difference between groups. A similar analysis of variance performed on the WRAT scores, however, showed differences between normal and poor readers even for the youngest subjects and showed the difference between groups to increase with age. This is reflected by a significant Group × Age interaction, $F(2, 64) = 13.80$, $p < .01$. Finally, no child was included if the hearing was impaired in either ear, or if there was evidence of emotional, sensory, or neurological handicaps.

Material and apparatus. The dichotic stimulus materials were recorded on tape with the aid of the computer facilities at the Kresge Hearing

TABLE 1

MEANS AND STANDARD DEVIATIONS (IN PARENTHESES) FOR SCORES ON THE PERFORMANCE SCALE OF THE WISC-R (PIQ) AND THE WIDE RANGE ACHIEVEMENT TEST (WRAT).

Age	Poor readers	Normal readers
	PIQ	
7	103.3 (5.33)	101.9 (3.47)
11	106.0 (10.91)	106.5 (6.50)
15	106.6 (9.47)	106.9 (10.40)
	WRAT	
7	2.21 (.68)	4.31 (1.11)
11	4.05 (.48)	7.52 (1.13)
15	6.19 (.54)	11.00 (.80)

Research Laboratory of the South.[1] Construction of the tapes involved recording one member of a dichotic pair on one channel while the other member was simultaneously recorded on the second channel.

The three types of stimuli used in this study were CV syllables, digits, and words. The CV syllables were comprised of the six stop consonants /b, p, t, k, d, g/, each followed by the vowel /a/. All of these syllables differed from each other on one or two dimensions, specifically voicing and/or place of articulation. The digits were the digits 1–9, excluding 7. The words were one-syllable high meaningfulness and high-frequency concrete nouns (Kucera & Francis, 1967).

Each type of stimulus was used to construct one set of dichotic listening trials with the exception of the CV stimuli which were used to create two sets. One set of CV trials (CV_1) involved stop consonant vowels arranged in pairs so that one member of each pair was presented to the left ear while the other was simultaneously delivered to the right. One pair of CV's constituted a trial for this task, a total of 60 trials comprised the set. The second set of CV trials (CV_2) consisted of four CV's arranged in two pairs. Two pairs of CV's instead of one, then, constituted a trial for this task, each pair within a trial being presented at the rate of one pair per half-second. There were 24 trials with CV_2 tasks. The digit and word tasks also had the stimuli arranged in pairs, with three pairs constituting a trial and 24 trials per set for both tasks. For each task, no stimulus ever occurred twice during any particular trial and, furthermore, each set of trials was constructed so that subjects heard each stimulus an equal number of times in each ear.

The dichotic material was presented to the subject by a four-channel Akai recorder and Yamaha HP-1 stereophonic earphones. Amplitude between channels was equalized and stimuli were presented at approximately 70 db as measured by an IVE audio analyzer. A sound attenuated room was used to test the children.

Experimental design. The performance on each task was analyzed separately. All four analyses were identical in design with each containing the two between subject variables Group (normal and poor readers) and Age (7, 11 and 15 years) and the within-subject variable, Ear of Presentation (right or left). The dependent measure for each analysis was the percentage correct recall.

Procedure. The hearing test had been administered by the school personnel and was obtained from the school records. The testing for reading and intellectual level was performed by the experimenter on each child individually in a separate session prior to the beginning of the experiment.

Each subject was given practice with monaural listening to insure that a correct identification could be made of each type of stimulus. Five dichotic practice trials were presented prior to each task. All subjects received all four dichotic listening tasks with the order of tasks balanced by a latin square over subjects. The lists were constructed so that each stimulus was presented to each ear an equal number of times. The position of the headphones was reversed for each subject after completion of half of each task in order to eliminate any variation resulting from the apparatus.

Subjects were told that they would hear the sound of a stimulus in one ear simultaneously with the sound of a different stimulus in the other ear. They were instructed to recall what they had heard in any order they chose. A 10-sec interval was provided for recall. Subjects were tested individually and each session lasted approximately 50 min.

Results

A separate three-way analysis of variance was performed on the percentage correct recall data from each task. Duncan's multiple-range test was used for all post hoc analyses, and the .05 level of confidence was adopted to indicate significance.

Digit task. What we see from the results of this study in Table 2 is that the normal readers recalled more digits than the poor readers and that the number of digits recalled increased with age for both groups and at about the same rate. Of more immediate interest was the fact that both normal and poor readers alike showed a right ear advantage and that, further, a comparable right ear advantage occurred for each age group. These conclusions are based on significant main effects of Group, $F(1, 64) = 22.60$, $p < .01$, Age $F(2, 64) = 14.39$, $p < .01$, and Ear $F(1,$

TABLE 2
MEAN AND STANDARD DEVIATION (IN PARENTHESES) OF PERCENTAGE CORRECT RECALL

	Digits		Words	
Age	RE	LE	RE	LE
7N[a]	81.9 (9.26)	71.81 (10.94)	75.11 (6.47)	60.53 (9.74)
7P	74.0 (9.56)	62.64 (10.15)	63.89 (9.06)	56.39 (4.78)
11N	88.2 (9.79)	83.3 (8.42)	76.5 (7.49)	70.14 (6.38)
11P	77.9 (9.71)	69.4 (9.49)	69.2 (7.14)	63.4 (8.86)
15N	91.5 (8.04)	84.6 (8.14)	81.3 (6.80)	69.7 (8.83)
15P	88.0 (6.58)	75.81 (7.53)	74.9 (20.31)	65.15 (6.93)
	CV_1		CV_2	
	RE	LE	RE	LE
7N	68.2 (10.42)	55.0 (8.15)	59.9 (10.98)	39.92 (11.15)
7P	53.0 (13.67)	53.0 (5.72)	44.0 (9.15)	42.3 (7.02)
11N	64.9 (8.93)	53.8 (5.00)	58.7 (13.73)	45.1 (12.71)
11P	58.5 (10.78)	48.9 (17.32)	48.1 (9.85)	45.5 (9.02)
15N	70.7 (9.88)	56.0 (8.33)	58.7 (6.56)	46.5 (7.27)
15P	67.9 (11.48)	45.7 (4.97)	84.9 (14.35)	34.0 (10.79)

[a] N, normal reader; P, poor reader.

$64) = 54.05$, $p < .001$, and the fact that the three-way Group $\times$ Age $\times$ Ear interactions was not significant $(F < 1)$.

Word task. The results of the word task are shown in Table 2 where it can be seen that, as with digits, normal readers recall more items than poor readers and that there is an increase in recall with age. It can also be seen that, again, both groups of readers show a roughly equivalent right ear advantage at each age. These conclusions are based on significant main effects of Group, $F(1, 64) = 29.07$, $p < .01$, Age, $F(2, 64) = 14.97$, $p < .01$, and Ear, $F(1, 64) = 34.26$, $p < .001$. None of the interactions approached significance. Thus, with both digits and words, poor as well as normal readers show a strong right ear advantage.

CV_1 task. As shown in Table 2, the ear difference or ear asymmetry for the normal readers on the task requiring recall of a single pair of CV syllables remains relatively constant across age groups with the right ear advantage emerging early and changing little with increasing age.

Poor readers, however, not only failed to show a right ear advantage prior to age 11, but experienced significantly less recall of material presented to the right ear than normal readers. By age 15, the right ear performance of poor readers approached a level comparable to that of the normal readers but recall of material presented to the left ear actually

declined. Post hoc analyses showed a significant right ear advantage at each age for the normal readers but only for the 15-year-old poor readers. The sharp decline in the recall of material from the left ear for the 15-year-old poor readers was offset by the significant improvement in performance on the right channel, which in effect acted to enhance their ear asymmetry.

The ANOVA on these data support the above conclusions with main effects of Group, $F(1, 64) = 17.34$, $p < .01$, and Ear, $F(1, 64) = 34.91$, $p < .001$. The Group $\times$ Age $\times$ Ear interaction did not reach significance [$F(2, 64) = 2.68$, $p < .10$] but the trends are in the same direction as for the CV_2 data where the three-way interaction did obtain.

CV_2 *task*. Normal readers, as depicted in Table 2, recalled better than poor readers and maintained a relatively constant right ear advantage across age. The greater performance for syllables presented to the right ear emerged early and showed little developmental change for the normal readers. Poor readers, on the other hand, showed equivalent performance on material from the left and right ears at ages 7 and 11. By age 15, recall of the right ear improved to a level of performance comparable to that of the right ear performance of normal readers while recall from the left ear drastically declined. These conclusions were verified by ANOVA with significant main effects of Group, $F(1, 64) = 23.30$, $p < .01$, and Ear, $F(2, 64) = 30.60$, $p < .01$, and the three-way Group $\times$ Age $\times$ Ear interaction, $F(2, 64) = 4.08$, $p < .05$.

Post hoc analysis revealed significant differences in performance for the material presented to the two ears at all ages for the normal readers, but only for the 15-year-old poor readers. Additional analyses also showed significant normal–poor reader difference in right ear performance at the youngest age and left ear performance at the oldest age. Finally, the marked improvement in recall from the right channel for the oldest poor readers was at the expense of their left ear performance since the mean left and right ear performance for these subjects was equivalent to the mean left and right ear performance for the 11-year-olds.

Discussion

The results of Experiment I revealed significant performance differences between normal and poor readers in recalling dichotically presented materials. Children with normal reading ability showed a right ear advantage at every age level and for all types of stimuli. Children classified as poor readers, on the other hand, showed a somewhat more complex pattern of results. While poor readers in the two younger groups did show a right ear advantage in recalling words and digits, they did not show such an asymmetry on the two tasks that used CV syllables as stimuli. The oldest poor readers showed a right ear advantage for all stimuli, but the right ear advantage for the CV syllables was offset by

a nearly equal decline in performance for syllables presented to the left ear. In other words, all subjects showed a strong right ear advantage for digit and word stimuli. It was only the CV task that discriminated between normal and poor readers.

The absence of age-related changes in the development of a right ear advantage for digits and words by both normal and poor readers would appear to be inconsistent with a theory positing a maturational lag in laterality of speech centers. Normal and poor readers as young as 7 years of age showed a right ear advantage for words and digits with no increase in the asymmetry with increasing age. There was no gradual developmental change in the asymmetry as predicted by the theory and the asymmetry had emerged prior to the age at which the complete lateralization of language functions was argued to occur (Satz & Van Nostrand, 1973).

The results of the CV syllable task also appear to offer little support for the maturational lag notion proposed originally by Satz and Sparrow (1970) though other delay explanations might be appropriate. The normal readers again showed a right ear advantage even at the youngest age tested and there was little or no change in the asymmetry in the older normal readers tested. There was a developmental change for the poor readers but not of a form that would support a theory that poor readers gradually "grow out of their problem" as a maturational lag notion would suggest. The 15-year-old poor readers do, indeed, show a strong right ear advantage but at the expense of left ear performance. The overall performance for this group was not much better than for the 11-year-old poor readers.

The levels of processing model proposed by Porter and Berlin (1975) also appears to have difficulty explaining our results. While the right ear advantage found with normal subjects on all stimuli fits their formulation, the absence of a right ear superiority for the two groups of younger poor readers with CV syllables is not easily handled. This theory also has difficulty in explaining the drop in performance for the oldest poor readers.

In sum, the data, at least for the normal subjects, give good support to the work of Kinsbourne and Hiscock (1977; Hiscock and Kinsbourne, 1978) in showing that lateralization occurs early in development and may not change much developmentally. What remains is to explain the findings of the poor readers.

One possible starting point for an explanation of our data is in the development of reporting strategies in the dichotic listening task. Malatesha (1976) used a procedure almost identical to our CV_2 task with the same syllables, recorded by the same computer (at the Kresge Hearing Research Laboratory of the South) and with the same population of subjects as in the present study. His data, shown in Table 3, demonstrated that both younger and older normal readers showed a tendency to recall

TABLE 3
Order of Report for CV Syllables from Malatesha (1976)

Age	Reading level	
	Normal	Poor
6–8	30.61	18.30
11–13	29.80	26.97

Note. These data represent the total number of syllables reported from the right ear first divided by the total number of syllables correctly reported.

material presented to the right ear first. While the order of report data for older poor readers looked very much like that of the normal readers, the younger poor readers showed a much smaller right ear preference. Assuming that we can extrapolate from the Malatesha study to our data, this would mean that the right ear advantage reported above might best be characterized as a consequence of reporting that material first and then recalling what was still available from the left ear. Through a rather sizeable oversight we did not collect data on the order of report in Experiment I and thus must fall back on making inferences from existing studies like Malatesha (1976) and Inglis (1960). We did, however, want to further examine this notion that the right ear advantage was best thought of as an immediate ear advantage, thus Experiment II was conducted constraining order of report.

EXPERIMENT II

Subjects were instructed prior to the presentation of lists on each trial to recall material presented to either their left or right ear first (immediate ear) followed by what they could report from the material presented to the other ear (delayed ear). The right ear was cued as the first channel to be reported from one-half of the trials with the left ear cued first on the other half of the trials. Of special interest was the size of the ear asymmetry effect produced when the right and left channels served as the immediate or the delayed ear of report, respectively. A significant difference in the amount of material recalled from the ears (immediate vs delayed) would lend some credibility to the importance of reporting strategies in determining ear asymmetry. In addition, the assessment of performance of poor readers in recalling material from a delayed channel was also considered important since the dramatic loss in left ear recall for the oldest poor readers on the CV tasks in Experiment I may have been due to a strategy of reporting material delivered to the right ear first, thereby causing greater output interference (as well as other factors

associated with delayed recall) for the material from the left or delayed ear. Such a deficit in recalling material from a delayed ear would serve to implicate memory processes or possibly rehearsal strategies as a cause in the normal-poor reader differences in Experiment I. In other words, in Experiment II we are interested in the extent to which normal and poor readers of various age groups can be discriminated because of differing levels of ear asymmetry and the extent to which they can be discriminated because of differing levels of asymmetry between immediate and delayed recall. While this study was conducted prior to the publication of Bryden's (1978) paper, this procedure of specifying order of report prior to presenting the items to be recalled fits with his suggestion for studying developmental differences in the dichotic listening task.

Method

Subjects. The 36 normal and 33 poor readers who participated in Experiment II were identical in description to those subjects utilized in Experiment I. They were drawn from similar age ranges to form the same three age groups and were required to meet the same criteria on intelligence and reading achievement previously established for each population. Means and standard deviations of PIQ and WRAT scores for the normal and poor readers are listed by age in Table 4. Due to a paucity of 7-year-old poor readers, only nine subjects were tested in this group. Two analyses of variance performed on subjects PIQ and WRAT scores, respectively, yielded only a significant Group × Age interaction, $F(2, 63) = 9.10$, $p < .05$, for level of reading proficiency. Again, no subject was included who evidenced sensory, neurological, or emotional handicaps.

TABLE 4
Means and Standard Deviations (in Parentheses) for Scores on the PIQ and WRAT

Age	Poor Readers	Normal Readers
	PIQ	
7	103.2 (3.70)	103.8 (5.41)
11	103.8 (6.41)	105.9 (7.35)
15	108.5 (11.30)	109.4 (8.46)
	WRAT	
7	2.17 (.46)	4.98 (2.19)
11	3.75 (1.15)	7.48 (.87)
15	6.57 (.64)	11.06 (1.26)

Materials and apparatus. Three of the four tasks in this experiment were the ones used in Experiment I: digits, words, and CV_2. It was felt that the CV_1 task would not be demanding enough to show memory differences thus a CV_3 task was used. Since all six of the CV syllables in the pool were used on each trial our speculation was that subjects would simply resort to guessing the remaining three CVs that were not included in recall from the immediate ear. Thus, subjects were required to recall only from the initially cued ear in the CV_3 task. In retrospect, particularly in light of Bryden's (1978) paper, it might have been preferable to have used the CV_1 task in this experiment as well. The apparatus was the same as for Experiment I.

Experimental design. Four analyses of variance were performed, one for each of the four tasks. The analyses were indentical in design (with the exception of the CV_3 analysis) with each containing two between-subject variables and three within variables. Three of the factors, specifically the two between variables of Group and Age and the within-subject variable of Ear were identical to those similarly labeled and described in Experiment I.

The two within-subject factors were Delay of Recall and Serial Position. Delay of Recall contained two levels, immediate and delayed. Since subjects were instructed to recall items from one channel prior to the other with the ear cued first being counterbalanced, each ear alternately represented both immediate and delayed recall. There was no delay of recall variable for the CV_3 task, however, since subjects were only required to recall items from the cued or immediate ear. Finally, serial position contained three levels for all the tasks except the CV_2 task which had, of course, only two postitions. The dependent measure used in each analysis was the percent correct recall.

Procedure. Subjects were screened for any peripheral hearing loss and evaluated for reading proficiency and intelligence in a manner similar to that described in Experiment I. Monaural listening and dichotic practice trials were also presented to subjects prior to each task.

Subjects were told that they would hear the sound of a stimulus in one ear, simultaneously with the sound of a different stimulus in the other ear. On half of the trials they were asked to report all of the material delivered to their right ear first followed by what they could recall from the left ear. The remaining half of the trials required recall of left ear material first followed by recall of right ear material. The examiner indicated verbally to subjects before each trial from which "ear" to start recall. The headphone of the ear which was to initiate recall was also touched by the examiner prior to presentation on each trial to serve as an additional cue. A 10-sec interval was provided for recall following each trial. The order of ear being recalled first was randomized.

Results

A separate five-way analysis of variance was performed on the recall data from each task with the exception of the CV_3 task which only contained four variables.

Digit task. While the main effect of Ear was highly significant, $F(1, 63) = 33.4$, $p < .001$, reflecting a small but highly reliable right ear advantage (68% for right ear vs 63% for left ear). This variable did not distinguish normal and poor readers or subjects of various ages since the interaction of Ear with Age approached $F = 1.0$. The Group × Ear interaction was in the direction of larger REA for normal readers (5%) than poor readers (3%) but also was nonsignificant.

Probably the most striking feature of the data, however, can be seen in Table 5. While the normal and poor readers showed very similar recall performance for the material from the immediate ear, there were marked differences in their performance on the material from the delayed ear. This was confirmed by significant main effects of Group, $F(1, 63) = 27.6$, $p < .001$, Age, $F(2, 63) = 39.6$, $p < .001$, and significant interactions of Group × Age, $F(2, 63) = 6.1$, $p < .05$, and Group × Age × Recall Delay, $F(2, 63) = 12.8$, $p < .01$. It is obvious that both groups did much better on the material from the immediate ear than from the delayed ear, however, the older normal readers improved their delayed ear recall to the point that this difference was sharply reduced for 11-year-olds and almost eliminated for the 15-year-old normal readers. The poor readers, on the other hand, showed a large decrement for the delayed ear material even for the older subjects. The 11-year-old group showed no increase over the 7-year-olds and the 15-year-olds showed only a moderate increase. The poor recall of digits from the delayed ear by poor readers was not constrained to either the left or right ear, that is, delayed recall was equally poor regardless of whether the delayed ear was left or right. This was supported by the nonsignificance of the Group × Ear × Recall Delay interaction, $F < 1.0$.

Word task. Like the digit task, the word task showed a small but highly reliable effect of Ear, $F(1, 63) = 37.5$, $p < .001$, reflecting better recall of words presented to the right ear (53%) than for words presented to the left ear (49%). Unlike the digit task, however, there was a small but significant interaction of Group × Ear, $F(1, 63) = 4.3$, $p < .05$, shown in Table 5. The right ear advantage was slightly larger for the normal readers (6%) than for the poor readers (3%). This different pattern of results for the normal and poor readers with respect to left and right ears was independent of whether the ear served as the immediate ear or the delayed ear since the Group × Ear × Recall Delay interaction was not significant, $F < 1.0$. In other words, the inferior recall of the poor readers from the delayed ear was not a consequence of a specific deficit in one ear or the other.

TABLE 5
MEAN AND STANDARD DEVIATION (IN PARENTHESES) OF PERCENTAGE CORRECT RECALL

Age	Digits		Words		CV_2	
	Imm.	Del.	Imm.	Del.	Imm.	Del.
7N	71.6 (9.54)	29.9 (17.94)	59.3 (6.97)	24.4 (12.82)	42.7 (4.98)	27.6 (7.5)
7P	68.4 (9.68)	30.4 (18.25)	53.7 (11.57)	26.8 (7.51)	38.6 (9.63)	20.6 (8.46)
11N	88.5 (7.10)	70.7 (15.46)	75.6 (7.83)	44.3 (8.32)	47.2 (7.94)	30.2 (5.85)
11P	82.3 (7.56)	30.8 (10.92)	72.0 (9.43)	24.1 (9.57)	18.5 (12.00)	21.0 (6.33)
15N	91.7 (4.90)	81.6 (11.25)	81.7 (8.47)	47.6 (12.18)	49.8 (12.25)	24.1 (10.94)
15P	85.6 (6.00)	54.0 (16.29)	76.3 (6.61)	29.2 (9.24)	45.1 (7.42)	24.5 (10.38)

As can be seen in Table 5, the significant interaction of Group $\times$ Age $\times$ Recall Delay, $F(2, 63) = 10.5$, $p < .01$, for the word data closely parallels that of the digit data. Recall from the immediate ear was nearly identical for normal and poor readers with a gradual increase over age. The normal readers also showed a gradual increase in recall from the delayed ear over age and indeed the slopes of the immediate and delayed means for the normal readers over age are virtually identical. The poor readers, however, showed no tendency for an increase in recall from the delayed ear for the 11- and 15-year-old subjects above that shown by the 7-year-old subjects. These conclusions were supported by main effects of Group, $F(1, 63) = 16.5$, $p < .001$, Age, $F(2, 63) = 26.7$, $p < .001$, and Recall Delay, $F(1, 63) = 928.5$, $p < .001$.

CV_2 *task.* These data also showed a highly reliable main effect of Ear, $F(1, 63) = 25.9$, $p < .001$, and, in addition, an interaction of Ear $\times$ Recall Delay, $F(1, 63) = 13.2$, $p < .001$. This reflects the fact that performance on the material from the immediate ear was better if that ear was also the right ear (50.0% vs 38.6%) but for the delayed ear it made little or no difference whether the ear was left or right (23.8% vs 25.4%). But, the Ear variable did not distinguish between the normal and poor readers since, while the Group $\times$ Ear interaction was in the direction of that found with the word task (6% REA for normals vs 4% REA for poor readers), it was not significant, $F = 1.3$, $p > .10$.

Table 5 shows that while there was an overall superiority of normal readers over poor readers, Group, $F(1, 63) = 7.7$, $p < .01$, the pattern of data for the two groups was similar. The Age $\times$ Recall Delay interaction, $F(2, 63) = 3.5$, $p < .05$, and the significant main effect of Recall Delay, $F(1, 63) = 322.9$, $p < .001$, showed that while the performance of both normal and poor readers from the immediate ear improved with age, the performance of both groups from the delayed ear was near chance for all age groups.

It is quite likely that the results of the delayed ear are constrained by a floor effect since this task was certainly the most difficult task used in this experiment for all our subjects and the delayed ear data reflect that fact. While the CV_3 task involved the presentation of more stimuli, the subjects only were required to recall from the side that was cued prior to the presentation of the syllables. Our subjects invariably complained about the difficulty of the CV_2 task more than the CV_3 task. Thus, the failure of Group to interact with Recall Delay or any other variable in the task should be viewed with some caution.

CV_3 *task.* The only effects of any consequence in the CV_3 task indicated that the normal readers showed a larger right ear advantage (57% vs 47%) than did the poor readers (52% vs 48%). This was supported by the significant main effect of Ear, $F(1, 63) = 25.8$, $p < .001$, and the interaction of Group $\times$ Ear, $F(1, 63) = 4.6$, $p < .05$. These effects

seemed to hold for subjects of all age groups since the main effects and interactions involving Age were all approximately 1.0.

Discussion

The goal of this experiment was to determine to what extent the recall performance of normal and poor readers is differentially affected by varying the ear to which the material was presented (and presumably some hypothesized difference in nervous system structure) and whether the material to be recalled comes from a source being recalled from immediately or after a delay.

For all four tasks there was a small but very reliable main effect of Ear reflecting an advantage for right ear material over left ear material. There was also a tendency, significant for the words and CV_3 tasks, for the normal readers to show a slightly larger right ear advantage than the poor readers. Across the four tasks (digits, words, CV_2, and CV_3) the right ear advantage was 5, 6, 6, and 10% for the normal readers ($\bar{X} = 6.75\%$) and 3, 3, 4, and 6% for the poor readers ($\bar{X} = 4.00\%$). Again, not a very large difference between normal and poor readers even in those cases where the difference was significant. This seems to confirm Satz' (1977) suspicion that lateralization, at least as indexed by dichotic listening performance only weakly differentiates normal and poor readers.

The variable Recall Delay, on the other hand, gave rise to very large differences between normal and poor readers for the digit and word task and probably would have on the CV task if it had been less difficult. Across the digit and word tasks, normal and poor readers showed similar levels of recall from the immediate ear and both showed gradual increases over age. There was a sizeable difference between the groups, however, in recall from the delayed ear. While the 7-year-old subjects for the two groups were alike in showing very poor recall from the delayed ear, the older subjects were very different for the normal and poor readers. Whereas the older normal readers showed a gradual increase in recall from the delayed ear compared to the 7-year-old normal readers, the 11-year-old poor readers showed only a moderate increase for digits and none at all for words when compared to the recall of the 7-year-old subjects. The fact that these differences in recall from the delayed ear for the normal and poor readers were not specific to either the right or left ear suggests that they are independent of the right-ear-advantage effects discussed earlier and that the two effects are mediated by different factors.

These results lead us to believe that differences between normal and poor readers in recall performance on dichotic listening tasks can best be explained by a three-factor theory. We would make a very tentative case that the ear asymmetry effect is probably a little bit larger in normal readers than in poor readers. There was a tendency, significant for words

and CV_3 stimuli, for the right ear advantage to be slightly larger in normal readers than in poor readers even in Experiment II when the order of reporting material from the two ears was signaled prior to stimulus presentation. Thus, we would argue that, for reasons that are probably neurological and thus outside the scope of this paper, normal readers have slightly better access to material presented to the right ear. Again, this is a tentative argument and in response to the first part of the question posed by our title we would have to give a strong "possibly—but only slightly."

A second factor, related to the first, has to do with order-of-reporting strategies. Younger poor readers do not show the same tendency shown by normal readers of all ages to recall material presented to the right ear first (Malatesha, 1976). On those occasions in which recall occurred first from the left ear, performance would be worse than on those occasions in which it occurred first from the right ear since even the poor readers show some right ear superiority. More importantly, a comparison of just right ear performance for the normal and poor readers would tend to accentuate the differences between them because it tends to compare the immediate recall of the normal readers with a combination of immediate and delayed recall for the poor readers.

The third factor is, we believe, much more responsible for performance differences between normal and poor readers on dichotic listening tasks. That factor is that poor readers simply have a memory deficit compared to the normal readers. So, the answer to the second part of the question posed by our title is a resounding "yes!". The support for this notion is the sizeable difference between the normal and poor readers in the recall from the delayed ear with digits and words in Experiment II. Rather sizeable memory differences between normal and poor readers have also been found in other studies (Cohen & Netley, 1978; Senf & Freundl, 1971; Torgesen & Goldman, 1977).

It is not at all clear what gives rise to this memory deficit in poor readers. Torgesen and Goldman (1977) and Torgesen (1977) have proposed that poor readers use less efficient rehearsal and retrieval strategies and that this in turn represents a general tendency of poor readers to employ less efficient strategies in all cognitive tasks. It could be, however, that the memory deficit occurs at a more basic level than rehearsal. Jackson and McClelland (1979) and Jackson (1980) have shown that one source of individual differences in the reading ability of mature readers is the speed at which the reader can access letter codes in memory. This same variable has been suggested as being responsible for individual differences in memory span (Chi, 1977) and deserves investigation as a possible source of the memory and reading level differences between children classified as poor readers and those who are classified as normal or good readers. The fact that the memory deficit in poor readers is

found with nonverbal material such as abstract forms (Morrison, Giordani, & Nagy, 1977) suggests that the problem may be even more basic than the labeling process. Since the stimuli were presented auditorially a further possibility is some problem in the precategorical acoustic store (Crowder & Morton, 1969).

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