# Speech Perception in Severely Disabled and Average Reading Children*

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ABSTRACT It has been hypothesized that children with specific disabilities in reading may have subtle auditory and/or speech perception deficits. To address this question, recent investigations have focussed on whether reading disabled children show categorical speech perception. These efforts have yielded equivocal results. The present study was designed to attempt to help resolve this controversy by comparing the performance of severely disabled readers with normal readers in four speech perception tasks. Results indicated that perception was significantly less categorical among the severely disabled readers in three of the four speech perception tasks. The possible implications of this small, but significant, difference are discussed.

RÉSUMÉ Il a été suggéré que des enfants ayant des difficultés à lire pouvaient avoir des déficits subtils d'audition et/ou de perception du langage. Les études qui se sont attaquées à ce problème ont produit des résultats pour le moins équivoques. L'étude présentée ici a tenté de résoudre cette controverse en comparant la performance d'enfants en difficulté de lecture avec des enfants normaux dans quatre tâches de perception du langage. Les résultats ont montré que la perception était significativement moins catégorique chez les enfants handicapés dans trois des quatre tâches. Les implications de cette différence, petite mais significative, sont discutées.

The relation between speech perception and the process of reading has been outlined previously (Godfrey, Syrdal-Lasky, Millay, & Knox, 1981). Basically, in reading, the printed word has to be mapped on to the underlying phonologic representation (Liberman, 1983; Read, 1971). This process includes converting individual graphemes to phonemes and strings of graphemes to the overlapping and highly encoded (Liberman, Cooper, Shankweiler, & Studdert-Kennedy, 1967) larger linguistic units such as syllables and words. In order to make this conversion, the reader must have a stable, context-independent phonological representation available on which to map the linguistic units.

Research in speech perception has shown that adults, children, and even prelinguistic infants tend to perceive speech sounds in a categorical fashion. That is, when presented with several varying naturally produced speech syllables or

when presented with computer synthesized speech syllables which vary according to equal steps along an acoustic continuum, subjects can discriminate between only those exemplars which they can label as members of different phonetic categories (Liberman et al., 1967). This *categorical* perceptual capability imposes an initial phonetic categorization on spoken language and is thought to provide the basis from which phonological categories are constructed.

Some researchers have postulated that subtle perceptual deficits may be causal factors in both specific language impairments (Hardy, 1965; Stark & Tallal, 1981; Tallal & Stark, 1981) and specific reading impairments (Boder, 1973; Tallal, 1980; Zurif & Carson, 1970). According to this line of reasoning, the subtle perceptual deficit makes it difficult to segment both oral and later written language into phonetic categories. Without a perceptually determined categorization process, the construction of abstract phonological categories could be impaired, and the tasks of learning to speak and read would be much more onerous. Other scholars have argued that subtle perceptual deficits result from, rather than cause, the language disabilities (Liberman, 1983; Morehead & Ingram, 1973; Vellutino, 1979). It is noted that perceptual boundaries typically sharpen (Garnica, 1973) as a function of linguistic experience. Thus, although young infants and young children show categorical-like perception, their boundaries between phonetic categories appear to be less sharp than are those in older children and adults. According to this line of reasoning, children with reading disabilities probably have other subtle and more fundamental language difficulties which, among other consequences, limit the influence linguistic experience can exert to sharpen initial boundaries. In any event, there is still currently a controversy as to whether children with specific reading difficulties even have speech perception deficits. Before we can address the issue of causality, it is important to determine whether these children do have difficulties in speech perception.

There have been only a few studies directly comparing speech perception performance between reading disabled (RD) and average reading children, and many of these studies have solely examined temporal processing (Tallal, 1980; Zurif & Carson, 1970). Recently, however, two studies have been reported which compared normal and dyslexic children on their ability to label and discriminate single syllable synthetic stimuli differing in equal acoustic steps along a /ba/-/da/ and a /da/-/ga/ place-of-articulation continuum (Brandt & Rosen, 1980; Godfrey et al., 1981). (Brandt and Rosen also compared these two groups on their perception of a VOT continuum.) Brandt and Rosen report no significant differences between control and dyslexic children on their performance. They concluded that subjects in all groups showed categorical perception in the labelling and discrimination tasks. This conclusion was based on the observation that the cross-over boundary locations were in the same position for subjects in both groups and that there was no significant group difference in the proportion of correct "same" discrimination responses.

Quite different conclusions were reached by Godfrey et al. (1981). On the basis of their data, they conclude that perception is significantly less categorical among dyslexic than normal readers. In their study, reading disabled children were

classified as dysphonetic and dyseidetic dyslexics according to Boder's (1973) screening task and compared with normal readers matched for age, sex, and hand preference. An analysis of variance showed that both groups of reading disabled children performed similarly. These children were more variable in their labelling of stimuli and had a less sharp boundary between phoneme categories than did normal readers. In addition, both groups of dyslexic children performed significantly more poorly in an AX discrimination task than did the control subjects, and the difference between predicted and obtained discrimination scores was greater. Each of these results indicates that speech perception is less categorical among the RD children.

In comparing their significant group differences to the nonsignificant differences of Brandt and Rosen (1980), Godfrey et al. (1981) point out that the identification and discrimination functions obtained by Brandt and Rosen are not as steep for the dyslexics as for the normal readers. Godfrey et al. suggest that if similar statistical analyses had been used by Brandt and Rosen, results consistent with their own might have been obtained. It should be noted that Brandt and Rosen do acknowledge the existence of slightly flatter discrimination functions for the dyslexic children, but feel this slight difference was not of importance.

The present study was designed to replicate and extend the previous work in an attempt to resolve this controversy. RD subjects were compared with matched controls on their performance in the identification and discrimination speech perception tasks used in the previously mentioned works. Data was analyzed in a manner similar to that used by Godfrey et al. (1981). Two additional speech perception tasks were included to assess the generalizability of any significant deficit in speech perception performance.

## Method

*Subjects:* The RD group was composed of 14 children attending a private school in New Westminster, British Columbia. All were of average or higher IQ and had no primary emotional problems or neurological damage. All had been diagnosed as reading at least 2 years below grade level[1] and were unresponsive to remediation in the public schools. There were 10 boys and 4 girls.[2] Performance and Verbal WISC-R IQ scores were available on all these children.

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[1] Reading scores in the form of WRAT, Grays and Iota scales are available for the disabled readers. However, the teachers at the private school for disabled readers felt these scores were not meaningful for a number of reasons. The children do very poorly in group testing, resulting in scores that underestimate their capabilities. Although they do much better in individual testing, such testing may be an overestimation due to practice effects since these children are given reading tests approximately four times every year. Reading disabled children were selected with the help of the teachers and the principal, and the group included children whose reading scores *and* teacher opinion indicated a deficit of at least 2 years below grade level.

[2] This group was initially divided into two subgroups differentiated on the basis of relative IQ. Both subgroups were matched for age, sex, and extent of reading disability. Subgroup 1 included children whose Performance IQ was at least 11 points greater than their Verbal IQ, and Subgroup 2 included children whose Verbal IQ was relatively equal to their Performance IQ ($< 7$ points difference). (These divisions are based on those suggested by Sattler, 1982.) Analyses showed that these two subgroups performed equivalently in every speech perception task. Given the lack of significant difference between subgroups and the lack of significant difference reported by Godfrey et al. (1981), all RD subjects have been classified into a single group for this paper.

TABLE I
Summary Characteristics of Children

| Group | Age range | Mean Age | Sex | Performance IQ Mean | Verbal IQ Mean |
|-------|-----------|----------|-----|---------------------|----------------|
| Reading Disabled | 8–14 | 10.3 | 10 M 4 F | 113.5 | 100.5 |
| Control | 8–13 | 10.5 | 10 M 4 F | 113.6 | 111.0 |

The control group was composed of children selected from the Vancouver public schools who were matched in age and sex to the disabled readers. These children were all reading within a year of grade level. Every attempt was also made to match for IQ; however, IQ tests are no longer routinely administered in the Vancouver schools. We were allowed to administer individual WISC-R tests if given parental permission and were able to get IQ scores on 11 of the 14 children. Summary characteristics of age, IQ, and sex for each group are given in Table 1. As can be seen, these groups are well matched for age, sex, and Performance IQ. As would be expected, the disabled readers had lower Verbal IQ scores. Although it is extremely important to control for IQ differences in research examining processing and strategy differences between normal and RD readers, there is no reason to suspect that IQ would affect speech perception performance. In addition, there were no significant differences between groups on overall IQ scores.

*Stimuli:* An eight-step /ba/-/da/ continuum was synthesized using the Mattingly synthesizer controlled by the VAX 750 computer at Haskins Laboratories. These stimuli were designed to contain a comparable number of acoustic cues to those /ba/-/da/ stimuli used by both Brandt and Rosen (1980) and by Godfrey et al. (1981). Since release bursts were not used in either of those experiments, they were also not used for the stimuli in the present experiment.

Each stimulus was 275 msec in duration. Fundamental frequency was steady at 100 Hz for the first 100 msec, then gradually decreased to 80 Hz during the remaining 175 msec, leading to the perception of a falling intonation contour. The first, fourth, and fifth formants were the same for each stimulus in the continuum. The first formant had a starting frequency of 500 Hz and a 50-msec transition up to a steady state frequency of 720 Hz. The fourth and fifth formants were steady state for the entire 275 msec at 3500 and 4000 Hz, respectively. The steady state portion of the second formant was set at 1090 Hz and at 2440 Hz for the third formant. The eight-step continuum was constructed by varying the starting frequency of the second formant from 900 to 1600 Hz in eight 100-Hz steps and that of the third formant from 2240 to 2912 Hz in eight 96-Hz steps. The duration of the formant transitions was 50 msec, and the duration of the remaining steady state portion was 225 msec. Schematic spectrograms of the first three formants of the first and eighth stimuli are shown in Figure 1.

Tapes for each task were prepared at Haskins Laboratories. The digitized stimuli were presequenced and recorded on to Scotch 1.5 mil polyester tapes with back treatment to minimize print through. The identification tapes consisted of four repetitions of each of the eight stimuli in a randomized order. There was a 3-sec interstimulus interval (ISI) between each of the 32 items. Discrimination tapes for three different types of tasks were constructed. For the AX (same/different) tape, all possible stimulus pairings were recorded. This resulted in 64 pairings including each stimulus paired with itself (e.g., 1-1) and each stimulus paired with each other stimulus in each order (1-4, 4-1, 1-3, etc.). There was a 1-sec ISI within pairs, and a 3.5-sec intertrial interval (ITI) between pairs.

In the ABX task (see procedure section for description) a tape containing triads of stimuli was recorded (e.g., ABA or ABB, where A and B each represent stimuli from the identification
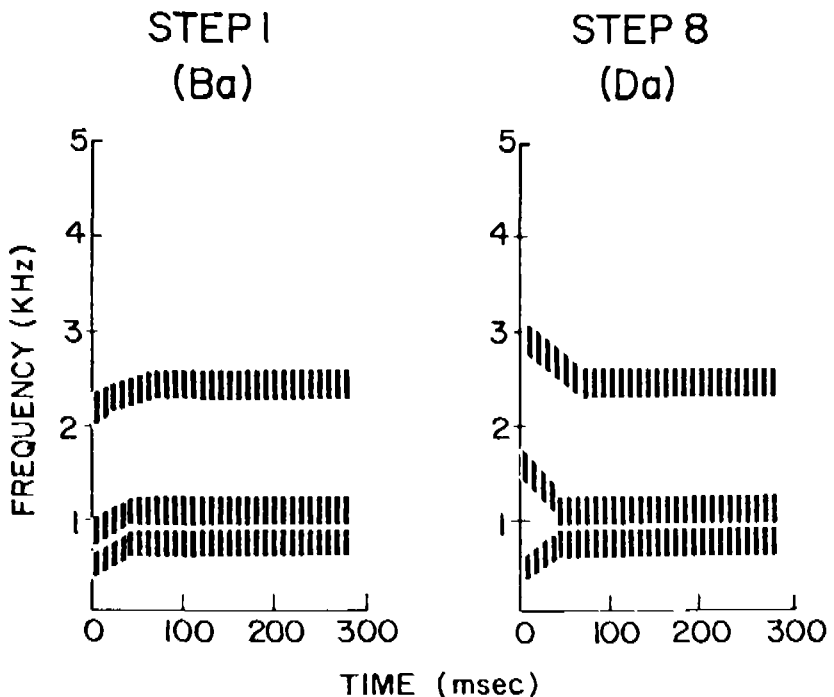
## STEP I
## (Ba)

## STEP 8
## (Da)



Figure 1. Stylized spectrograms indicating the values of the first three formants of Steps 1 and 8 from the /Ba-Da/ continuum.

task). The first two stimuli, A and B, represent two different stimuli from the eight-step continuum; the third is either A or B. All possible nonidentical pairings (e.g., 1-2-1, 1-2-2, 1-3-1, etc.) were recorded. There was a 500-msec ISI and a 3.5-sec ITI.

Two-track tapes were constructed for use in the category change tasks. One or two stimuli from the eight-step continuum would be recorded on Track 1 in random order, with the one or two stimuli to be discriminated from those lined up for onset time and recorded on Track 2. Four tapes were used. Two contained pairings corresponding to within-category discriminations (.e.g, /ba/ vs. /ba/), and two contained pairings corresponding to between-category pairings (e.g., /ba/ vs. /da/). The within-category pairings were Stimuli 1 and 2 (Track 1) versus 3 and 4 (Track 2) and Stimulus 2 (Track 1) versus Stimulus 4 (Track 2). The between-category pairings were Stimuli 3 and 4 (Track 1) versus Stimuli 5 and 6 (Track 2) and Stimulus 4 (Track 1) versus Stimulus 6 (Track 2). There was a 2-sec onset-to-onset time, with a resultant ISI of 1725 msec.

*Apparatus:* Tape-recorded test stimuli were played on a Revox B-77 2-track reel-to-reel tape recorder to a single driver speaker situated in an IAC sound attenuated room. Free field rather than head phone presentation was used to make the listening conditions somewhat more similar to those used in everyday speech processing. Output level was set at approximately 75 db SPL.

*Procedures:* The speech perception tasks were administered in the following order: (1) /b-d/ identification test, (2) /b-d/ ABX discrimination test, (3) /b-d/ AX discrimination test, and (4) /b-d/ category change discrimination task. All subjects were given Tasks 1 and 2 on Day 1 and were given Tasks 3 and 4 on Day 2.

Subjects were first familiarized with the experimental room and with each experimental procedure. While many investigators (e.g., Godfrey et al., 1981) require subjects to reach a pretest criterion in each experimental procedure before proceeding to testing, we included "dummy" control trials in each task. This would allow us to assess task performance during the testing procedure. That is, instead of just presenting subjects with all the 1- or 2-step pairings in the AX and ABX discrimination tasks, we included all possible pairings. We reasoned that if subjects understood task instructions and did not show a primary attentional deficit, performance on the highly distinct pairings (such as a 7-step pairing) should be close to perfect. We thus included those highly distinct pairings as control trials.

In the identification task, children were told they would be hearing a list of short syllables. They were instructed to listen to each syllable carefully and push one of two marked buttons to indicate whether the syllable sounded more like a /ba/ or a /da/.

In the ABX task, subjects were told they would hear triads of syllables and that they should indicate (by pressing one of two buttons marked *1* and *2*) whether the third stimulus sounded more like the first or second. In the AX task, they were told they would hear pairs of syllables, half of which would be the same and half different. Subjects were to press one of two buttons marked *S* and *D* to indicate whether the stimuli were the same or different.

In the category change task, subjects were told they would hear continuous repetitions of one (or two) stimuli. For example, the subject would hear two /ba/'s (e.g., Stimulus 3 and Stimulus 4) repeatedly at 2-sec intervals. At irregular intervals (every 4–15 stimuli) subjects would be presented with either a change or a control trial. During a change trial, they would be presented with a short series of stimuli from the contrasting /da/ category (e.g., Stimulus 5 and Stimulus 6). During a control trial, they would be presented with three more repetitions from the same /ba/ category (Stimulus 1 and Stimulus 2). Subjects were instructed to press a button indicating detection of the change. Correct button presses to change trials only were signalled by a brief flashing light (3 sec) and were recorded as hits. In addition to hits, all subjects could be scored as having missed a change trial, given a false alarm to a control trial, or a correct rejection to a control trial (for a more complete description of this task, see Werker & Tees, 1984).

Before each test the experimenter made sure each child was comfortable in the testing chamber and understood task instructions. Each child was thanked and encouraged before and after each task. At the end of the second day of testing, children were given a gift certificate to McDonald's.

## Results

*Identification:* The group identification functions are shown in Figure 2. The eight stimulus items from each continuum are shown on the abscissa, and the proportion of times each item was labelled as /ba/ is shown on the ordinate. As is evident, there is a relatively steep labelling function for each group. Subjects consistently label the first three stimuli as /ba/, and the last three as /da/, with a cross-over point around Stimulus 4. However, it appeared that the identification functions for reading disabled subjects might be less categorical than the functions for their matched control group. To explore this possibility, the data were analyzed in a manner similar to that used by Godfrey et al. (1981). We used a $2 \times 8$ (group by stimuli) mixed-groups analysis of variance with group as the between factor and stimuli as the within factor. The proportion of times a stimulus was labelled /ba/ was the dependent variable. As would be expected, there was a main effect for stimuli, $F(7, 182) = 5.281, p < .001$. This was, of course, accounted for by subjects calling the first several stimuli /ba/ and the last several stimuli /da/. Of interest to the hypothesis, the overall difference between the reading disabled and control subjects was nearly significant as was evident in the
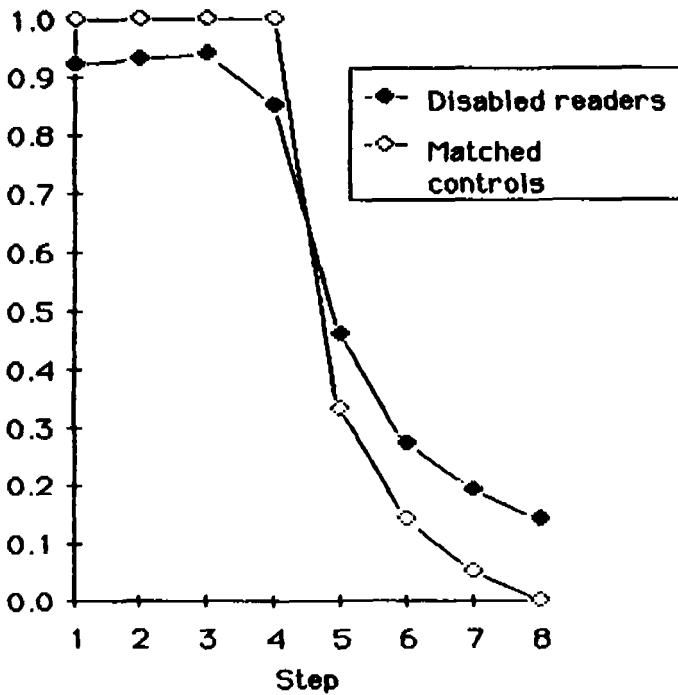
Figure 2. Proportion of /Ba/ responses by group on the labelling task.

group by stimulus interaction, $F(7, 82) = 1.920, p = .068$. The performance of normal and disabled readers is shown in Figure 2.

*Discrimination:* The results of the AX discrimination test will be reported first since this is the discrimination task that was used in previous research. Subjects were presented with all possible pairing types. The data from the 1- and 2-step pairings were analyzed as indices of categorical type perception, and data from the 7-step pairing was analyzed as control trials to ensure all subjects could perform in the task.

The group discrimination data are shown for the 1- and 2-step pairings in Figures 3 and 4. The pairings are indicated on the abscissa, and the proportion of times a pairing was called different is indicated on the ordinate. As would be predicted from previous speech perception research, discrimination is generally good between stimuli which are identified as belonging to different phonetic categories and poorer between stimuli which are labelled as belonging to the same category. The solid line indicates the scores the subjects actually obtained, and the dashed line indicates the predicted scores. Individual predicted discrimination scores were computed from individual identification data using the same formula as that used by Godfrey et al. (1981, p. 412). This formula was derived from Pollack and Pisoni's (1971) 21AX paradigm and predicts discrimination directly

from individual identification functions. According to this formula, if subjects show absolute categorical perception, the obtained discrimination functions will precisely match the predicted functions. Any deviation indicates something less than perfect categorical perception. Although obtained scores never precisely match predicted scores, degree of categorical perception can be inferred by comparing subjects on their predicted and obtained scores (cf. Liberman et al., 1967; Pollack & Pisoni, 1971).

The difference between predicted and obtained discrimination scores served as the dependent variable.[3] It was first necessary to analyze performance on the 7-step pairing (Stimulus 1 in the continuum paired with Stimulus 8). If subjects could not perform this very easy perceptual discrimination, that would indicate they could not perform in the procedure. The data were analyzed with a one-way ANOVA. As would be predicted for this pairing, there were no differences even approaching significance.

Of interest to the hypothesis of this study, results for the 1- and 2-step pairings indicated that perception was less categorical for the RD than for the control subjects. In the first analysis, a $2 \times 7$ (group by pairings) mixed ANOVA was conducted using the difference scores on the seven 1-step pairings. This yielded a main effect for both group, $F(1, 26) = 5.724, p < .05$, and pairings, $F(6, 156) = 2.91, p = .01$, and a significant group by pairings interaction, $F(6, 156) - 2.119, p = .05$.

A $2 \times 6$ (pairings) ANOVA of the difference scores for the 2-step pairings yielded a main effect for group, $F(1, 26) = 13.406, p = .001$, and pairings, $F(5, 130) = 5.9, p < .001$, but no significant interaction. The lack of interaction is explained by the significantly greater difference between predicted and obtained scores for the RD subjects than for the controls for every 2-step pairing.

A similar series of analyses was applied to the ABX discrimination scores. Predicted discrimination scores were obtained for each individual for each pairing using the formula outlined by Pollack and Pisoni for ABX tasks (1971, p. 291). As in the case of the AX task, the difference between predicted and obtained discrimination scores was computed and served as the dependent variable. The two groups were first compared on their difference scores for the 7-step pairing to make sure RD subjects could perform in the task. Although there were no significant differences between groups, subjects in both groups performed very poorly even on the 7-step pairing, indicating that the ABX task may have been too difficult for young children. Further analyses showed there to be no significant main effects or interactions for either the 1- or the 2-step pairings. These results can be interpreted either as indicating that discrimination, as measured by the ABX task, is as categorical in nature for the RD children as it is for the control

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[3] This is a similar form of analysis as that used by Godfrey et al. (1981). However, instead of using the difference scores as the dependent variable, Godfrey et al. used a more complex ANOVA where one of the factors had two levels – predicted and obtained discrimination scores. They were still looking for overall group differences between predicted and obtained discrimination scores, but because of the design of the ANOVA, had to look in the interaction term. By simply entering the individual difference scores between predicted and obtained values, main effects could be examined in the present study.
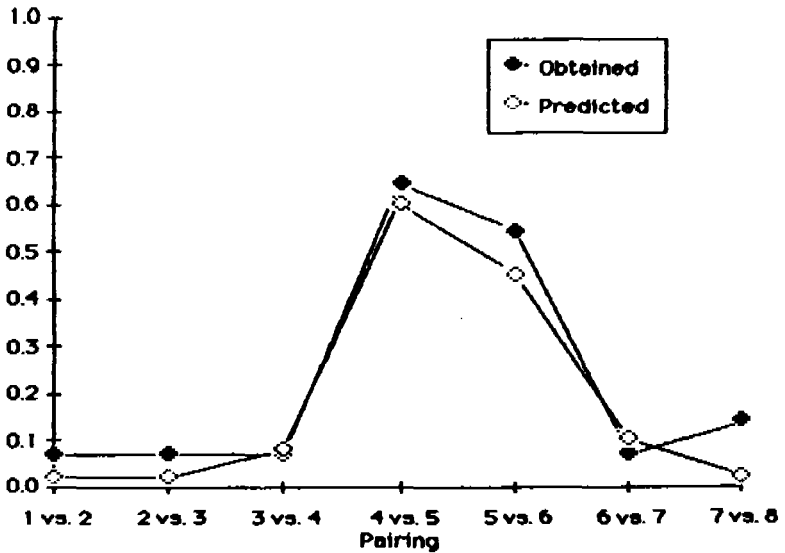
## Disabled Readers
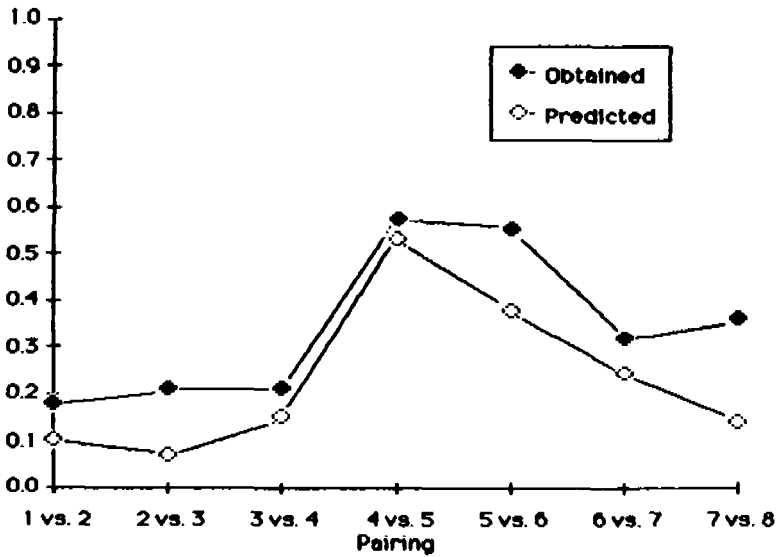


## Matched Controls



Figure 3. Mean obtained and predicted different responses for the disabled readers and the matched controls on the 1-step AX discrimination task.
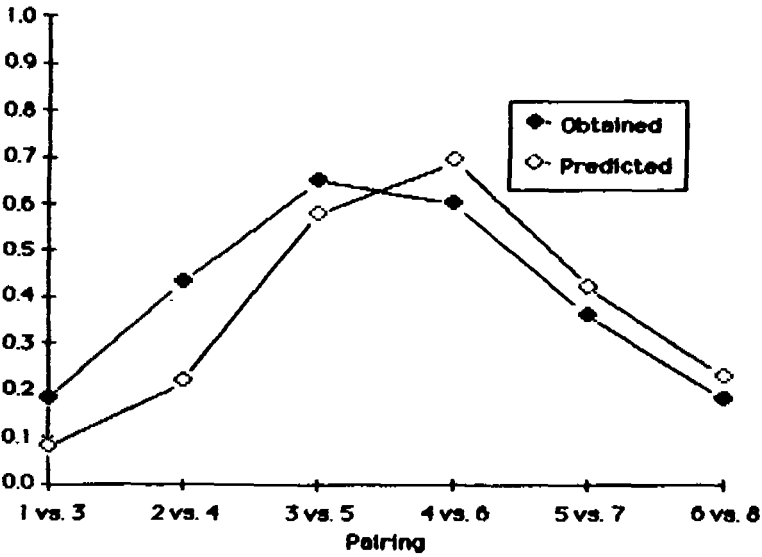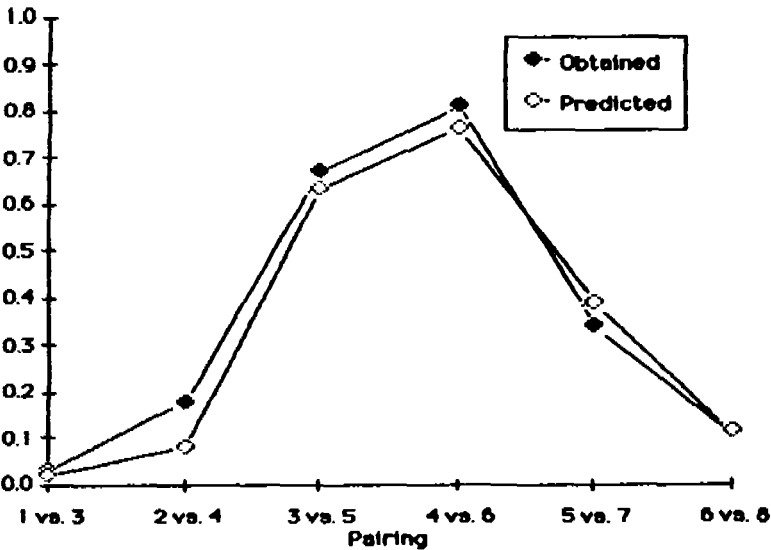
Figure 4. Mean obtained and predicted different responses for the disabled readers and the matched controls on the 2-step AX discrimination task.

children, or as indicating that the ABX task is inappropriate for use with young children and that the lack of significant differences on the 1- and 2-step pairings results from the obvious floor effect.

In the category change task, subjects were given 30 test trials. These trials occurred at irregular intervals every 4–15 tokens. Approximately half were change trials and half were control trials. Subjects were scored as having either reached or not reached a predetermined criterion. Criterion was met if subjects responded correctly to at least 8 out of 10 consecutive change trials, with a maximum of either two misses or two false alarms. The proportion of subjects reaching criterion in each group was then compared using an analysis of proportions based on a $\chi^2$ analogue to the Scheffé Theorem (Marascuilo, 1966).

For analysis, the data were also collapsed across the two within-group comparisons (Stimuli 1 and 2 vs. 3 and 4, and Stimulus 2 vs. 4) and across the two between-group comparisons (Stimuli 3 and 4 vs. 5 and 6, and Stimulus 4 vs. 6). This resulted in a mixed 2-group design. Results are shown in Figure 5. The analysis of proportions indicated that there were overall differences between groups, $\chi^2(1) = 34.24$, $p < .01$. Multiple comparisons revealed that this overall significance was accounted for by a higher proportion of subjects in the control group reaching criterion on the between category comparisons than did the RD subjects. These results indicate that in the category change task, perception is more categorical among the control than among the RD subjects.

## Discussion

These results indicate that the disabled readers differed from the average readers in three of the four speech perception tasks administered. This was evident in a tendency toward less categorical perception by the disabled readers in the labelling task and in both the AX and category change discrimination tasks. Such a difference was not evident in the ABX discrimination task.

These results are consistent with those recently reported by Godfrey et al. (1981) indicating that perception is less categorical among RD subjects than it is among average readers. Obviously, these results also refute the conclusion drawn by Brandt and Rosen (1980) that perception is equally categorical among RD and average readers. When the present results are compared with both previous studies, two factors are evident:

(1) The form of the labelling functions was almost identical among all three studies. Although a significant difference is reported by Godfrey et al. (1981) and by the present study and not by Brandt and Rosen (1980), the labelling curves in all three studies indicate a slightly less categorical curve for the RD. Whether this difference achieved significance or not, it seemed to exist in all three studies. Nevertheless, in all three studies, the difference between the curves seemed to be very small.

(2) In the analysis of performance in the AX task, again Godfrey et al. (1981) report significant differences and Brandt and Rosen (1980) do not. Following an analysis similar to that used by Godfrey et al., we also report significant differences. However, as in the case of the labelling data, the form of the obtained
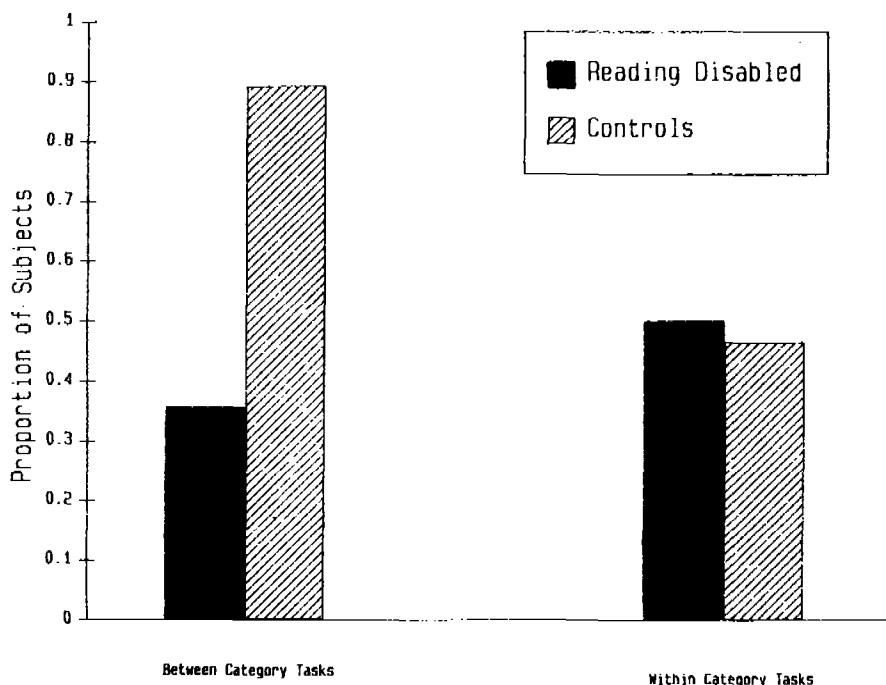
Figure 5. Proportion of subjects reaching criterion on the category change task.

discrimination functions was similar across all three studies, indicating a consistent but small (and thus not always significant) difference between RD and normal readers. Although Brandt and Rosen did not report significant differences, they did acknowledge this flatter discrimination function among their subjects and discussed the possibility that perception may be less categorical among this group. They argue, however, that since the difference is so small, it cannot be a causal factor in reading disabilities.

In considering the small but consistent differences in speech perception that emerged in the present study as well as in the previous two studies, we would disagree with Brandt and Rosen (1980) and suggest that these small but consistent differences in speech perception *are* related to reading performance. In particular, it is proposed that these difficulties may indicate that the phonological categories are less robust among disabled than among normal readers. A less robust representation should be more subject to disruption under stress. Given that reading is a stressful activity, particularly in the early stages of learning (Gough & Hillinger, 1980), less robust phonological categories would result in difficulty mapping the orthography on to internal representations.

Support for the hypothesis that the phonological categories are less robust among RD subjects is provided by two recent studies. Brady, Shankweiler, and Mann (1983) compared normal and slow readers on their ability to discriminate both speech and nonspeech sounds under ideal and noisy listening conditions.

Results showed that slow readers could discriminate both the speech and nonspeech sounds nearly as well as the normal readers under ideal listening conditions. As would be expected, under noisy conditions both groups showed a significant decrement in performance for both speech and nonspeech sounds. However, although this decrement was equivalent between the two groups for the nonspeech sounds, it was significantly greater among slow readers than among normal readers in the case of the speech sounds. These results indicate that the subtle deficit among slow readers which is evident under ideal listening conditions is greatly exacerbated under noisy listening conditions. This is consistent with the hypothesis that the phonological categories are less robust among disabled than among normal readers.

The results of a second study with severely reading disabled teenaged boys (Werker, Bryson, & Wassenberg, 1985) also supports the hypothesis of less robust phonological categories among disabled readers and indicates how this deficit might be expressed in a reading problem. RD and normal reading teenage boys were compared on their performance while reading and spelling nonsense words. The RD boys made a series of mistakes which indicated that they could not access underlying abstract phonological categories and, instead, had to rely on the sensorimotor (articulatory) representation of the sound/symbol correspondence.

Additional research is required to test the proposed hypothesis of this study further. Also, more research is required to determine whether this less stable phonological representation is caused by a primary perceptual deficit (cf. Tallal, 1980) or is the result of other subtle language difficulties resulting in lack of boundary sharpening. A consideration of previous research in the development of speech perception supports either of these possibilities. Speech perception research has shown that initial (innate) phonetic perceptual sensitivities are the initial building blocks used in constructing meaningful phonological categories (Eimas, Siqueland, Jusczyk, & Vigorito, 1971; Werker & Tees, 1984), but it has also shown that the advent of oral communication skills functions to sharpen existing phonetic category boundaries (Garnica, 1973). Thus it is possible that the subtle differences in speech perception performance that have been identified between RD and control groups may be caused by a primary perceptual deficit or that they may be a secondary perceptual deficit resulting from subtle difficulties in the use of spoken language. It is necessary to separate these two possibilities in order to isolate the most useful form of remediation for children with reading difficulties.

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