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ABSTRACT

The dichotic listening paradigm in relation to specific reading disability was investigated with 58 severely disabled readers and 58 above-average readers (all 9-year-old males). Comparison of scores from a Dichotic Digits Task and Dichotic Sides and Types Tasks indicated that disabled readers performed worse than controls in the overall right-ear effect, and demonstrated the ineffective use of strategies by disabled readers when they were specifically instructed to report dichotic materials by sides (left/right ear) and types (digits/letters of the alphabet) of stimuli. The concept of reading disability as retardation in the acquisition of skills rather than the loss of abilities was supported. (IM)

Listening Selectively: Some Implications from Dichotic Listening Studies for Disabled Readers

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Abstract

Listening Selectively: Some Implications from Dichotic Listening Studies for Disabled Readers

This paper discusses the dichotic listening paradigm in relation to specific reading disability. In the three dichotic listening studies the children were 116 nine-year-old boys divided into an experimental group of 58 severely disabled readers and a control group of 58 above-average readers equated simultaneously on age and general ability. In the Dichotic (Digits) study, a 2 group x 2 half-span x 3 series length ANOVA repeated measures showed disabled readers performed significantly worse in the overall right-ear effect as compared with their controls. The Dichotic (Sides) and Dichotic (Types) studies, both using digits and letters of the alphabet, demonstrated the ineffective use of strategies by disabled readers when they were specifically instructed to report dichotic materials by sides (left/right ear) and types of stimuli (digits/ letters of the alphabet). The studies taken as a whole support the concept of reading disability as "retardation" in the acquisition of various skills rather than the loss of abilities. The importance of efficient use of rules and strategies is emphasized.

LISTENING SELECTIVELY: SOME IMPLICATIONS FROM DICHOTIC LISTENING STUDIES FOR DISABLED READERS

Dichotic listening is the experimental procedure of presenting simultaneously different messages of stimuli (usually digits, letters, or words) to different channels of sense organs (usually the two ears or the dichoptic analogue of the ear and the eye). The methods which have been used to separate one message from the other include the use of different people speaking, intensity differences, and the insertion of band-pass filters into the channel carrying one of the speech messages. The most effective cue has been found to be some form of spatial separation of the voices either by using different loudspeakers arranged laterally around the listener, or by using stereophonic headphones in which one voice is heard in one ear and one in the other. It has been shown that messages localized 180° apart as in dichotic listening do not stimulate both ears together. In general, under free-recall conditions with verbal materials presented fairly rapidly (usually two pairs per second) most listeners perceive more of the right ear messages accurately. This is referred to as the right-ear advantage (REA).

The deceptively simple dichotic procedure is usually attributed to the experiments on selective attention by Broadbent (1954). He, in turn, acknowledged his debt to the concurrent work of Cherry (1953; Cherry & Taylor, 1954) as among those who have studied the effect of selective listening and report strategies on dichotic right-ear advantage. Since

then and especially with Kimura's (1961a, 1961b) pioneering work relating dichotic listening to pathological brain functions, dichotic studies have been extended to exceptional children. Different groups have been studied within this experimental paradigm related to perceptual and memory processes: mentally retarded children (Jones & Spreen, 1967; Neufeldt, 1966); hearing impaired children (Ling, 1971); high and low achievers (Conners, Kramer, & Guerra, 1969), and disabled readers (Bryden, 1970; Sparrow & Satz, 1970; Leong, 1976; Zurif & Carson, 1970). The purpose of this paper is to discuss some dichotic studies with nine-year-old children with specific reading disability. The experimental questions include: First, are disabled readers poorly lateralized as tested dichotically? Second, are disabled readers deficient in their use of rules and tactics as shown in dichotic studies?

Theoretical Postulate

When Orton (1925, 1929, 1937) wrote some fifty years ago about the relationship between cerebral dominance and specific reading disability he was ahead of his times. He postulated that the reversals and mirror images of letters and words in dyslexic children were due to the confusion of competing patterns of excitation (engrams) in both hemispheres because of a failure to establish unilateral cerebral dominance. More direct, empirical evaluation of Orton's postulate awaited the advent of experimental procedures in audition (dichotic listening) and vision (visual hemi-field perception) in the early 1960's.

One explanation of the dichotic right-ear advantage is the functional

and morphologic asymmetry of the human brain. Sparks and Geschwind (1968) suggest that materials from one ear have two pathways for reaching the ipsilateral temporal lobe. One route is the direct one via the ipsilateral auditory pathway. The other route follows the longer but stronger contralateral pathway to the opposite temporal lobe and then returns via the corpus callosum to the ipsilateral temporal lobe. This explanation is shown schematically in Figure 1.

Insert Figure 1 about here

Geschwind and Levitsky (1968) have provided evidence from post-mortem examinations on 100 adult human brains to show marked anatomical asymmetries between the upper surface of the human right and left temporal lobes. The planum temporale (the area behind Heschl's gyrus) is longer on the left in 65 percent of the brains; on the right it is longer in only 11 percent. The left planum is on the average one-third longer than the right planum. This area is part of Wernicke's area and makes up part of the temporal speech cortex. Thus the anatomical asymmetries correlate with the dominance of the left hemisphere for speech and language function. More recently, Witelson and Pallie (1973) have shown a comparable asymmetry in newborns. A schematic representation of the structural asymmetries of the brain is shown in Figure 2.

Insert Figure 2 about here

Another, but much less powerful, explanation of the dichotic right-ear advantage is Broadbent's (1954) filter theory of selective attention. This ascribes superior performance of speech information to one channel over the other but does not of itself sufficiently explain why.

In addition to perceptual and memorial processes there are other factors contributing to or affecting the dichotic right-ear advantage for speech sounds. An example is onset synchrony of pairs of dichotic stimuli as shown in the oscillographic tracings in Figure 3 (see also Leong, 1975).

Insert Figure 3 about here

Researchers in psycho-acoustics at the Haskins Laboratories and the Kresge Hearing Research Laboratory, among others, have also emphasized acoustic (e.g., intensity, signal-to-noise ratio, frequency bandwidth), phonetic and linguistic (e.g., CV syllables as |pa| versus digits, letters, words) parameters.

METHOD

Subjects

The subjects for the study were 58 boys severely "retarded" in reading by two and a half grades or more. Their mean chronological age was 111.07 months and their mean Lorge-Thorndike non-verbal IQ was 102.45. These boys were compared with a control group of 58 above-average readers (all boys) drawn from the same schools and equated on age (mean of 110.93 months) and Lorge-Thorndike non-verbal IQ (mean of 107.57). There was no

significant difference on these variables between the groups as tested conjointly with the multivariate Hotelling T^2 method,

Dichotic Tasks and Procedure

A Dichotic Listening (Digits) test was used to tap speech lateralization. The stimulus materials consisted of a dichotic list of 3 sets of digits drawn from 0 to 9 with 5 series in each set ranging from 2-digit pair (2 digits to each ear) to 4-digit pair series. The counter-balanced design was used in testing the children, who were asked to report all the digits heard. The scoring method was that of ear order scoring where the first digit reported denoted the half-span recalled first and the correct serial position of the stimulus was taken into account.

Two further dichotic tests (digits and letters) were used to tap the differential use of strategies. In Dichotic (Sides) a list of 12 series of 3-element pairs consisting of a combination of 3 digits and 3 letters of the alphabet selected from "a, e, i, o, u, y, l, m, r, x" was used. The child was instructed to report all the elements heard in one ear first and then those elements heard in the other ear (report by <u>sides</u>). For Dichotic (Types) a list drawn up in a similar way to Dichotic (Sides) was used. The child was instructed to report either all the numbers first, or all the letters first irrespective of half-spans (ears). This is the report by <u>types</u> strategy. As before, the counter-balanced design was used in testing the children. The main scoring method was that of <u>serial</u> scoring which took into account the correct serial position of the stimuli according to the pre-instructed strategy.

RESULTS AND DISCUSSION

Dichotic (Digits) Task

In the Dichotic (Digits) experiment it was hypothesized that the experimental and control groups would show an overall right-ear effect with the latter group showing significantly higher right-ear scores. This hypothesis of overall lateralization was tested with a 2 group × 2 half-span × 3 series length ANOVA with the last two factors repeated. The proportions correct for the total scores summed for each set (2-digit, 3-digit, or 4-digit pairs) of 5 series were subjected to arcsin transformations and these latter scores were used in the analyses. All the main effects were significant with an F-ratio for group = 10.35, $p < 0.001$; for half-span F = 26.49, $p < 0.001$ and both with 1/114 df while for series length F = 132.10, $p < 0.001$ for 2/228 df. None of the interaction effects was significant. For clearer interpretation the arcsin transformations were reverted to proportions before graphing. Figure 4 shows the ear-for-ear inter-group differences for the three series lengths.

Insert Figure 4 about here

The ANOVA results demonstrate the overall right-ear dichotic effect for both disabled and non-disabled readers considered as groups. When finer group responses were analyzed disabled readers performed significantly worse in the overall right-ear advantage as compared with their controls. This differential performance is taken as prima facie evidence of a lag in functional cerebral development of the disabled readers.

Dichotic (Sides) and (Types) Tasks

Mean scores for each of the strategies of recall by sides (ears) and by types for both serial and free scoring for the experimental and control groups are shown in Figure 5. For the more stringent serial

Insert Figure 5 about here

scoring the disabled readers seem not to be able to use differential strategies as shown by the almost identical mean sides and types scores of 24.84 and 24.93, with a slight variation of the standard deviations. For the control group, however, the "tag" effect must have taken place as evidenced by the higher mean scores for the types recall. In other words, the group resorts to the strategy of reporting elements with contents as instructed (digits/letters) rather than the more "natural" sides (ears) report. The tag advantage, however, is lost with the control group with free scoring which is less discriminating than serial scoring. With two groups × strategies repeated measures ANOVA for both serial and free scoring the main effects for group are highly significant (for serial scoring $F = 72.496$, $p < 0.001$ and for free scoring $F = 47.729$, $p < 0.001$; both with 1/114 df). With serial scoring the sides/types strategy is also significant ($F = 4.317$, $p = 0.03997$ for 1/114 df), while the interaction hovers round a p of 0.051. With free scoring the strategies effect is not significant. Thus from the more refined serial scoring the hypothesis relating to the inefficient use of strategies in processing dichotic materials by disabled readers is upheld.

GENERAL DISCUSSION

The Dichotic (Digits) experiment provided some evidence for a lag in functional cerebral development of the nine-year-old disabled readers. This explanation of slightly poorer right-ear performance without implying that disabled readers have better left-ear scores or that children with better left-ear scores are necessarily at risk is consonant with the cerebral maturation lag postulate of Satz (Satz & Sparrow, 1970; Satz & Van Nostrand, 1973). While a lag in the magnitude of ear asymmetry in older disabled readers (age above 8 years) as reflecting laterality is cautiously advanced as having some substance; no generalization can be made to younger children. In critically reviewing cerebral dominance and reading disability, Satz (1976) warns of the danger of such an extrapolation because of methodological problems of ceiling and floor effects and of varying validity of laterality tests. He points out the even greater danger in any inductive inference on individual subjects to classify them into hemispheric dominance groups. This is because the base rates concerning hemispheric lateralization are so markedly asymmetric in the population as to favour left-brain speech lateralization. From his own study of left-handers who became average-superior readers Satz suggests the possibility of ear asymmetry as more related to handedness than to reading disability per se. While this suggestion has yet to be confirmed, the ongoing studies of Satz and of others illustrate the magnitude of the problem in relating dichotic speech perception to laterality and reading disability.

If this position of Satz needs verification, the equally cautious

view of Bakker (Bakker, 1973; Bakker, Smink, & Reitsma, 1973; Bakker, Teunissen, & Bosch, 1976) that the dominance-reading patterns are different at different stages of the learning-to-read process deserves attention. Very briefly, Bakker finds that proficient reading at an advanced stage of reading acquisition goes with left hemisphere dominance only, while the early stage of learning-to-read may go with either left or right dominance. The shift in cortical mechanism is predicated on the premises that there is a shift from perceptual analysis to semantic-syntactic analysis as the child advances in his acquisition of reading.

This brings us back to the implications of the Dichotic (Digits and Letters) experiments. Elsewhere, the writer (Leong, 1976-1977) has highlighted the nature of the cognitive process underpinning reading. Learning to read involves "structural thinking." Not learning to read can be better understood in the inefficient use of rules by children.

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Figure Caption

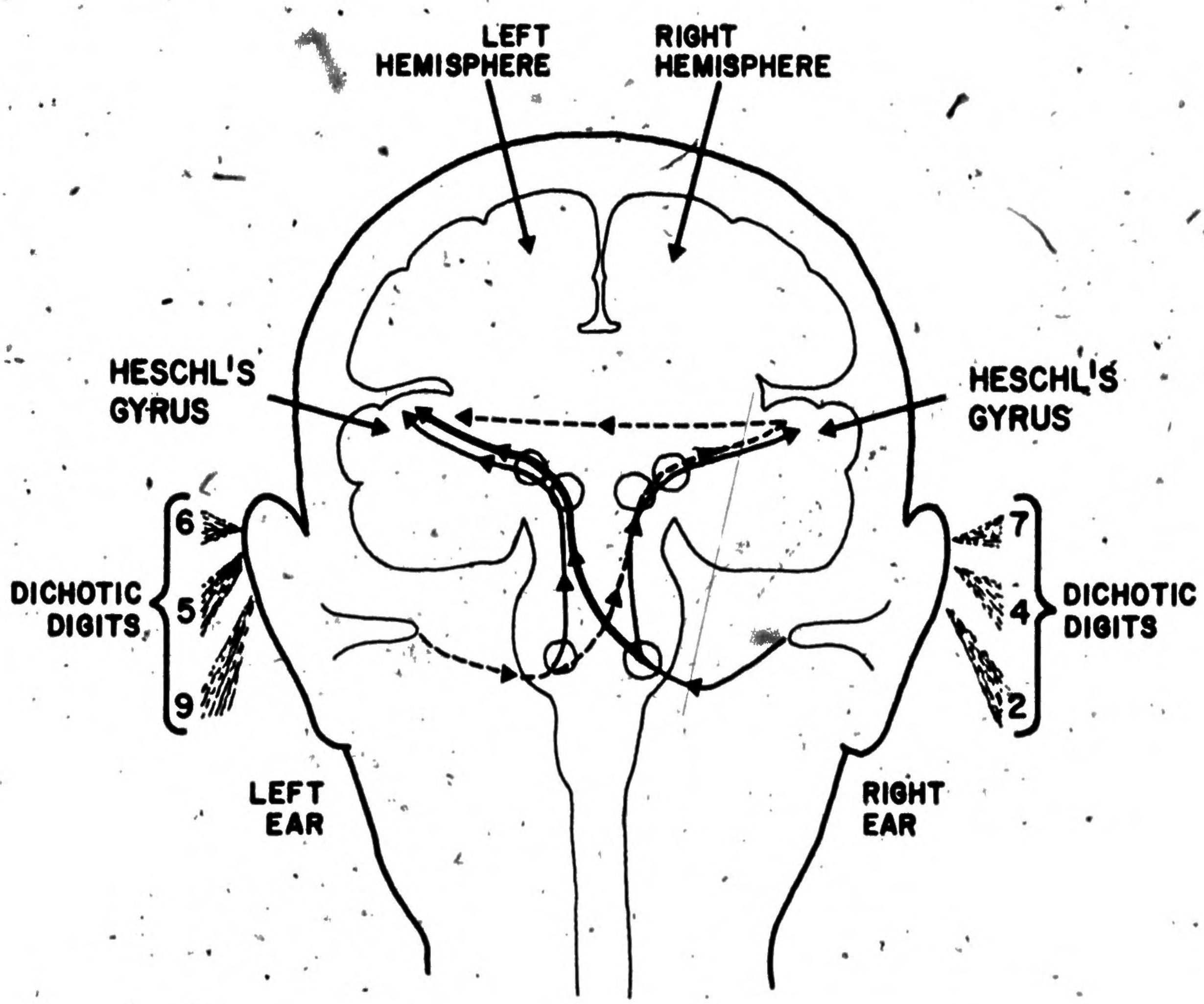
Figure 1. Schematic representation of crossed auditory pathways in dichotic listening. The neural connections from one ear to the hemisphere on the opposite side are stronger than the connections to the hemisphere on the same side. The broken line represents the indirect (perhaps more important) route from the left ear to the dominant left temporal lobe. (After Kimura, 1973; Sparks & Geschwind, 1968.)

Figure 2. Sketch of horizontal section through the human brain. The planum temporale (shaded) lies behind Heschl's Gyrus containing the primary auditory cortex. Note the larger size of the planum on the left. (From Geschwind, 1973, with permission.)

Figure 3. Sample oscillographic records displaying acoustic patterns of pairs of syllables in temporal alignment. Top record shows pair of digits "1", "3" in each channel from top down. Bottom record shows pair of digits "2", "4" in each channel in the same order. Each division represents a time duration of 50 msec.

Figure 4. Ear order ear for ear inter-group mean proportions (from arcsin transformations) for varying series lengths.

Figure 5. Differences in recall as a function of strategies (sides and types) for each group.



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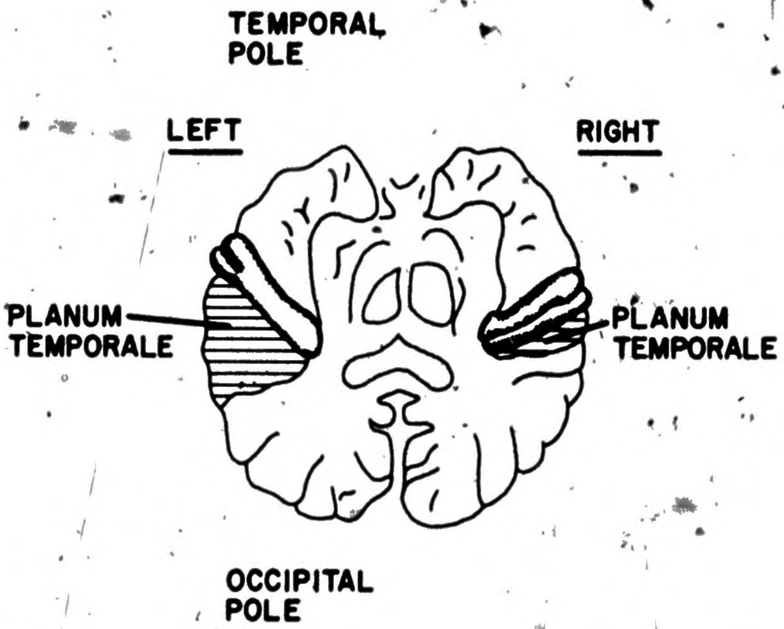

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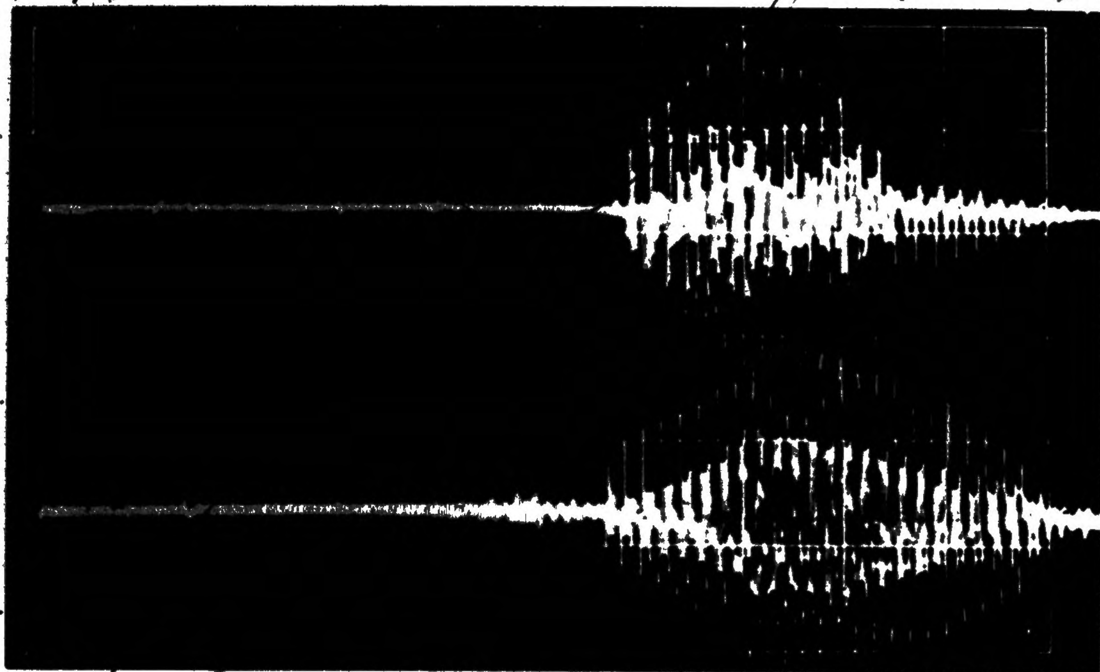

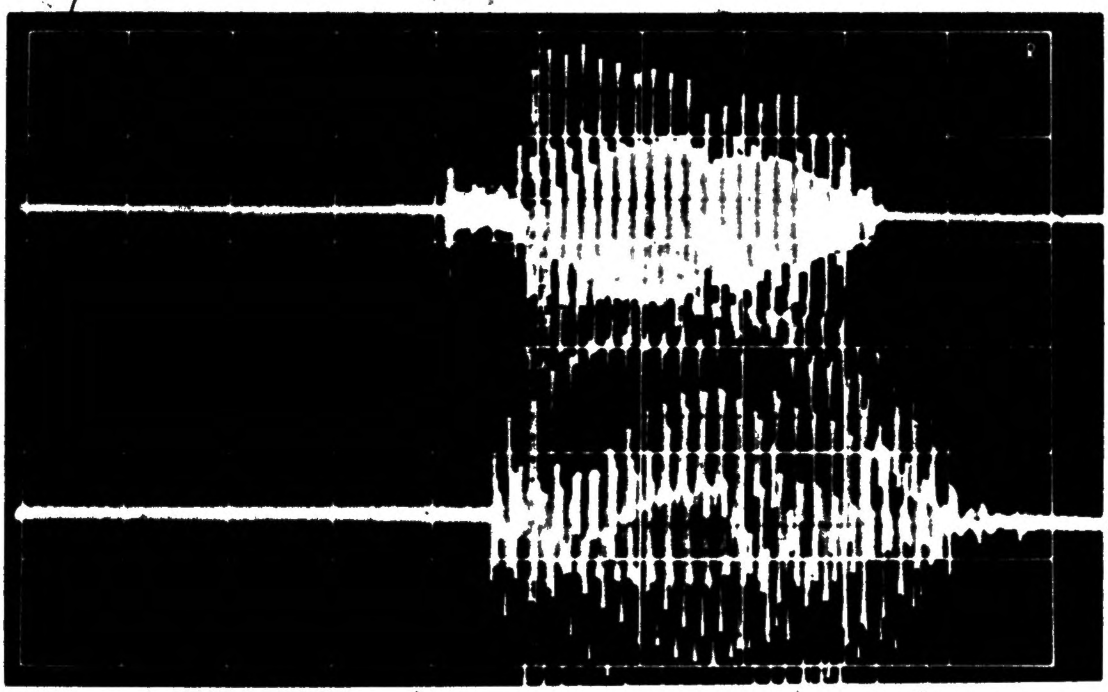

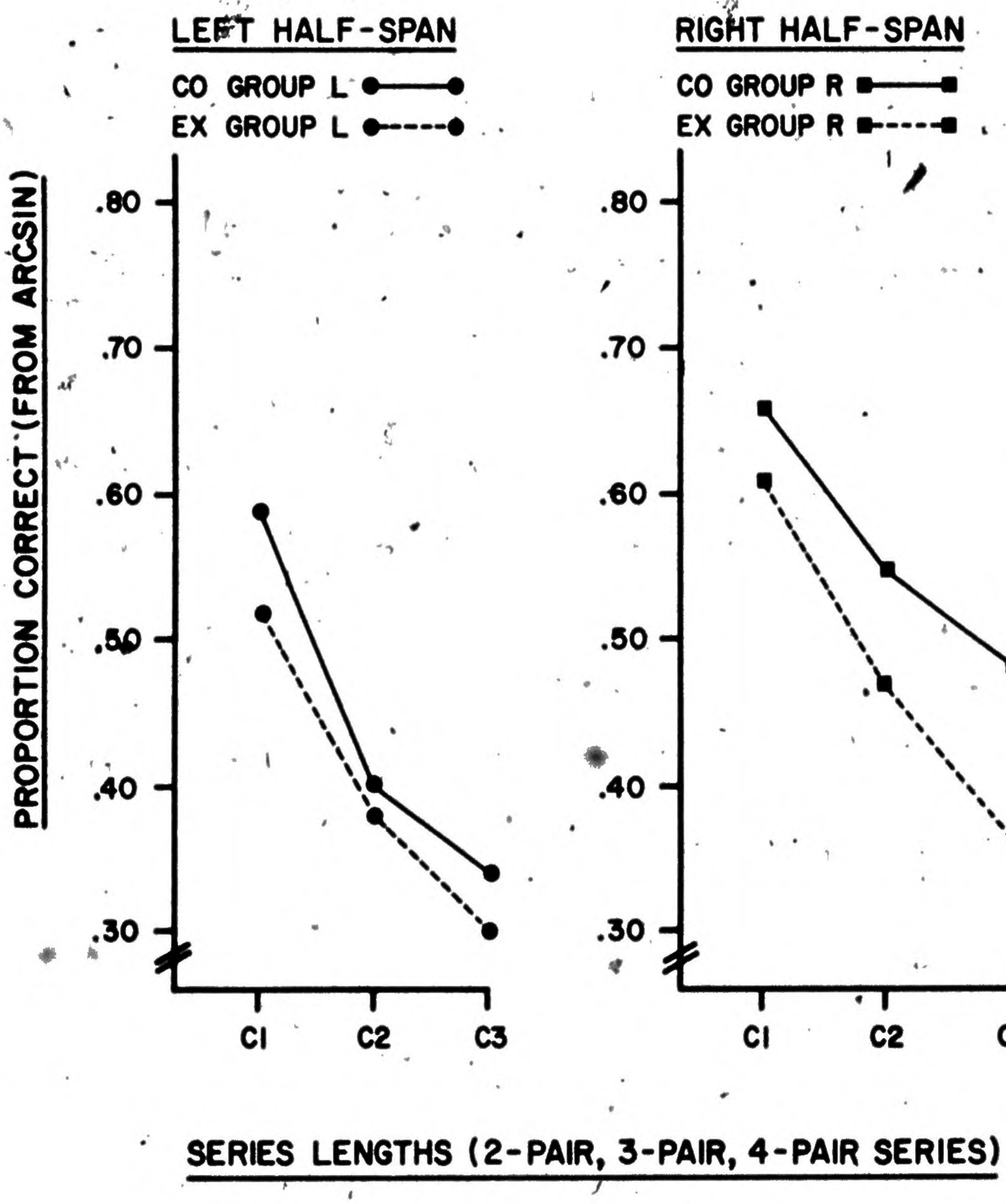

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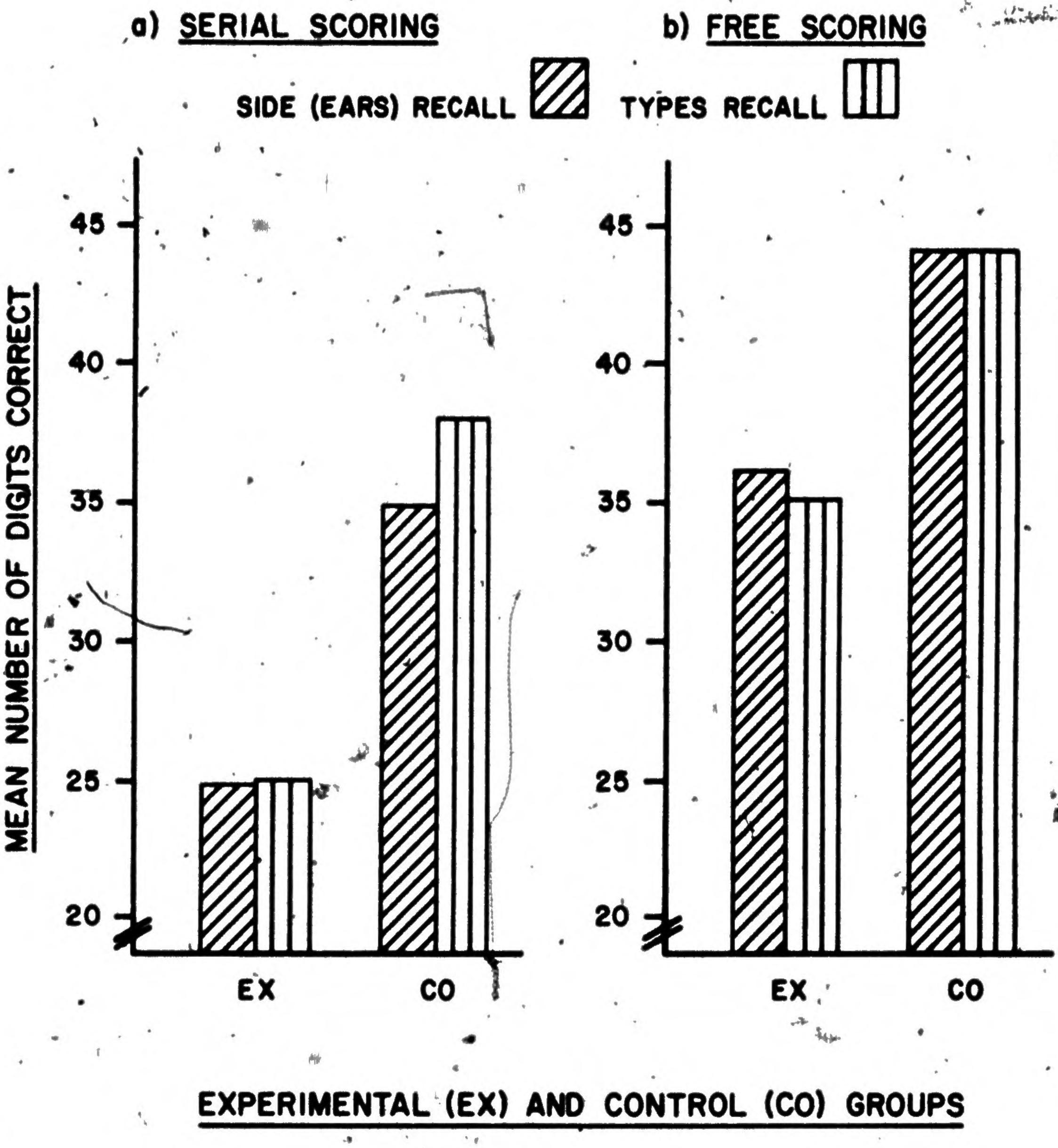

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