

M. F. Dorman and D. S. Geffner

Hemispheric specialization for speech
perception in six-year-old black and white
children from low and middle
socio-economic classes

Reprinted from CORTEX
Vol. X, 1974, pp. 171-176

CORTEX is an international journal devoted to the study of the interrelations of the nervous system and behavior, particularly as these are reflected in the effects of brain lesions on mental functions.

The editor in chief is Prof. Gildo Gastaldi (*Clinica delle Malattie Nervose e Mentali, Via F. Sforza 35, Milano, Italia*). Coeditors are Prof. J. de Ajuriaguerra (Genève), Prof. E. Bay (Düsseldorf), Prof. Arthur L. Benton (Iowa City), Dr. Macdonald Critchley (London), Dr. G. Ettliger (London), Dr. Norman Geschwind (Boston), Dr. Robert J. Joynt (Rochester, N.Y.), Prof. F. Lhermitte (Paris), Prof. A. R. Luria (Moskva), Prof. K. Poeck (Aachen) and Dr. J. Semmes (Bethesda).

Articles may be submitted in English, French, German, Italian or Spanish to the editor in chief or to coeditors. Each article must include a detailed summary both in the original language and in English.

Subscription rate per volume (4 numbers): \$ 16. Subscriptions should be sent to CORTEX c/o La Tipografica Varese, Via Tonale 49 Varese, Italia.

HEMISPHERIC SPECIALIZATION FOR SPEECH PERCEPTION IN SIX-YEAR-OLD BLACK AND WHITE CHILDREN FROM LOW AND MIDDLE SOCIOECONOMIC CLASSES

M. F. Dorman and Donna S. Geffner

(Haskins Laboratories, New Haven, and Lehman College of the City University of New York)

On dichotic listening tests with adults, when verbal stimuli are presented simultaneously to the left and right ears, the stimuli presented to the right ear are recalled better than those presented to the left ear (Broadbent and Gregory, 1964; Bryden, 1963; Curry and Rutherford, 1967; Kimura, 1961a; Shankweiler and Studdert-Kennedy, 1967). This right-ear advantage (REA) presumably reflects the functional prepotency of the contralateral auditory pathways and the left hemisphere's specialization for the perception of speech (Kimura, 1961b; Milner, Taylor and Sperry, 1968; Studdert-Kennedy and Shankweiler, 1970).

In children the REA appears to vary as a function of age, sex, and socioeconomic class (SEC) background. Kimura (1967) found that low SEC females and high SEC males and females evidence a REA at age five, whereas low SEC males do not evidence a REA until age six. Recently Geffner and Hochberg (1971) have reported a large (age) \times (SEC) interaction in the development of the REA. Four- to seven-year-old Ss from both low and middle SEC backgrounds were presented a dichotic digits task (cf. Kimura, 1963). The middle SEC Ss evidenced a REA at all ages. The low SEC Ss did not evidence a REA until age seven. These data led Geffner and Hochberg to speculate that children from low SEC backgrounds may not develop left-hemisphere specialization for speech at the same rate as children from more privileged SEC backgrounds.

The Geffner and Hochberg data are very striking for they suggest that cortical lateralization of function, which has been thought to be maturationally determined (Lenneberg, 1967), may be radically slowed down by environmental deficiencies during development. The nature of the environmental conditions which determined the performance of the low SEC Ss is, however, not at all clear. One nonenvironmental variable which may have affected the outcome of the Geffner and Hochberg study was the large proportion of black children in the low SEC group. Conceivably the delayed

lateralization of speech found for the low SEC population may have been a racial effect interacting with socioenvironmental variables.

To clarify the effects of race and SEC as determinates of the REA in children, in the present study, six-year-old black and white children from both low and middle SEC backgrounds were presented a dichotic syllable test (cf. Studdert-Kennedy and Shankweiler, 1970). To minimize a possible source of experimental bias, the groups of children were tested by an examiner of their own race.

MATERIALS AND METHOD

Subjects

The Ss were 52 six-year-old children (C.A. 6.0-6.8): 26 white Ss, 13 each from low and middle SEC; 26 black Ss, 13 each from low and middle SEC. SEC was determined by Hollingshead's Two Factor Index of Social Position (Hollingshead, 1955) which takes into account the parents' educational level and occupational status. All Ss were right-handed (handedness tasks are detailed in the *Procedure*) and had normal hearing with no known perceptual, neurological, speech, or language deficit. Children with a bilingual background were not selected. The Ss were matched as well as possible by class placement and performance. Because intelligence quotients are not available in New York City public schools, the authors obtained all information pertaining to the parents' occupation and educational level, the home environment of the Ss, and classroom performance from the classroom teacher, principal, guidance counselor, or parent.

Apparatus

The stimuli were reproduced on a Roberts 1920 stereo tape recorder via matched TDH-39 headphones. The output of each tape channel was calibrated and monitored by a Hewlett-Packard voltmeter. A 1000 Hz tone on both channels of the test tape was used as a calibration signal. Audiometric threshold tests were administered on a Maico MA-10 portable audiometer calibrated to ISO standards.

Preparation of stimuli

With the aid of the Haskins Laboratories' computer-controlled parallel resonance speech synthesizer, the stop consonant-vowel syllables /ba, da, ga, pa, ta, ka/ were generated. Each stimulus was composed of three formants, and was 300 msec. in duration. Under computer control these six stimuli were then combined into the 15 possible pairs (no stimulus was paired with itself) and were recorded dichotically in a fully balanced order onto magnetic tape. The resulting tape contained 60 stimulus pairs with each member of a pair occurring twice on each channel. The interstimulus interval was 4 sec.

Procedure

Each S was tested in a quiet room, most often the school nurse's. All Ss were first given an audiometric threshold test. Hearing level at 500 Hz,

1000 Hz, 2000 Hz, and 4000 Hz was assessed. If the hearing level between the two ears differed by 10 dB or more for two of the test frequencies, the *S* was excluded from further testing. Handedness was determined by asking the *Ss* to perform three manual motor tasks: throwing a ball, cutting with scissors, and drawing a circle. Any *S* who did not perform all three tasks with his right hand was not tested further.

After the preliminary examination, the *Ss* were presented binaurally three repetitions of the syllables /ba, da, ga, pa, ta, ka/. The *Ss* were instructed to listen with both ears and report the syllable heard. Any *S* unable to repeat the six syllables after the third repetition of the list was excluded from further testing. Next, the *Ss* were presented three dichotic practice trials. Again the *Ss* were instructed to listen with both ears and report the syllable heard. (Since the *Ss* were not told there were two different stimuli on these and the following dichotic trials, only one response was elicited.) The *Ss* were told that these sounds would sound "funny," but to continue reporting them as before. The *Ss* were then presented the 60-item test sequence, followed by a brief rest, then the 60-item test again. To control for possible channel effects, the headphones were reversed after each 60-item test. The black *Ss* were tested by a black student assistant, while the white *Ss* were tested by a white examiner.

RESULTS

Each *S*'s performance was scored in terms of the metric $\frac{R-L}{R+L} \times 100$

where *R* is the total number of items correctly reported from the right ear and *L* is the total number of items correctly reported from the left ear (for a discussion of this scoring technique see Studdert-Kennedy and Shankweiler, 1970). The mean score for each of the groups subcategorized by sex is shown in Table I.

Each (race) \times (SEC) group's mean score was evaluated by *t* tests for correlated samples against the hypothesis that there was no difference in

TABLE I
Magnitude of the REA for All Groups in Terms of $\frac{R-L}{R+L} \times 100$

		Race	
		White	Black
SEC	Middle	Males (N = 5) = 15.19 Females (N = 8) = 14.53 Ave. (N = 13) = 14.86	Males (N = 5) = 9.69 Females (N = 8) = 16.72 Ave. (N = 13) = 12.17
	Low	Males (N = 4) = 0.02 Females (N = 9) = 9.54 Ave. (N = 13) = 7.14	Males (N = 11) = 10.15 Females (N = 2) = 10.22 Ave. (N = 13) = 10.16

accuracy of report between the left and right ears. As shown in Table II, all groups evidenced a significant REA.

TABLE II
Mean Number of Syllables Correctly Reported for Each Ear

Group	N	Left	Right	t
Black low SEC	13	35.00	42.92	3.50**
Black middle SEC	13	34.76	44.86	2.26*
White low SEC	13	41.46	47.87	2.86*
White middle SEC	13	33.61	48.38	2.19*

* $p < .05$; ** $p < .01$

To determine whether the magnitude of the REA differed as a function of race or SEC, the individual scores were collapsed over sex into an analysis of variance with race and SEC as treatment variables. Neither the race ($F_{1/48} = .021$, $p > .05$) nor the SEC ($F_{1/48} = 1.009$, $p > .05$) main effect was significant. The (race) \times (SEC) interaction, suggested by the reduced REA for the low SEC white Ss, was not significant ($F_{1/48} = .405$, $p > .05$).

Statistical analysis of male-female differences was not attempted because of the generally small sample size, especially for males ($N = 2$) in the black low SEC condition. Because two of the four male white low SEC Ss evidenced rather large left-ear advantages, no overall ear advantage occurred for this group. There is no reason to suspect that the obtained REA is representative of the entire white male low SEC population.

DISCUSSION

Development of the REA

The magnitude of the REA averaged over all groups was 11.08. This magnitude REA is well within the range of REA's found for adults (Studdert-Kennedy and Shankweiler, 1972). The similarity in REA of the six-year-olds and adults suggests that cortical lateralization for speech perception may be established by age six (also see, Berlin, Lowe-Bell, Hughes and Berlin, 1972; Krashen and Harshman, 1972).

Racial factors in REA

No difference in magnitude of the REA was found between black and white Ss. A similar outcome is reported by Sadick (in preparation). Black and white five- and seven-year-old Ss were presented a dichotic syllable test

similar to that used in the present study. At both the five- and seven-year levels, both black and white Ss evidenced a REA. The magnitude of the REA did not differ between the groups. We may then tentatively conclude that the rate of cerebral lateralization of function does not vary as a function of racial origin. This conclusion is, of course, limited to the racial groups and SEC environments studied.

SEC factors in REA

The presence of a significant REA in the low SEC groups, although conflicting with the outcome of Geffner and Hochberg (1971), is consistent with the outcome of a recent study by Knox and Kimura (1970). These investigators assessed cerebral lateralization for speech and nonspeech sounds in five- to eight-year old low SEC Ss. The Ss were presented both dichotic digits and dichotic environmental sounds. In the digit condition, all age-sex groups evidenced a REA. Thus, in Kimura's several studies of the REA in five-year-old low SEC Ss (Kimura, 1967; Knox and Kimura, 1970) both males and females have evidenced REAs, although males less consistently than females.

These data, paired with the significant REA in the six-year-old black and white low SEC Ss found in the present study, suggest that at least some, perhaps the majority, of low SEC Ss achieve left-hemisphere specialization for speech at the same rate as higher SEC Ss.

One possible explanation for the difference in outcome between the present study and that of Geffner and Hochberg (1971) is that the low SEC Ss examined by the latter investigators may have been raised in more deprived environments than those of the present study. Geffner and Hochberg argued that abnormal rearing conditions may have resulted in a retarded rate of cerebral lateralization of function. However, an alternative and somewhat less radical explanation is that abnormal rearing conditions engender Ss who function at very low cognitive and motivational levels. Such Ss might perform "indifferently" on a relatively complex task like dichotic digits, especially when tested by someone not of their own race. On this view, it would be expected that Geffner and Hochberg's four-, five-, and six-year-old low SEC Ss would evidence very low overall performance levels on the digits task. An analysis of the Geffner and Hochberg data has indicated that, indeed, the low SEC Ss reported only 53% of the total possible digits, while the middle SEC Ss reported 62%. Thus the low SEC Ss evidenced a significantly lower performance level ($t_{154} = 3.98, p < .001$). This outcome suggests that the absence of a REA in the low SEC Ss may have been a "floor effect" (cf. Halwes, 1969) resulting from task difficulty and motivational variables. To choose between the alternative explanations for the absence of a REA, it would appear necessary to present four- and

five-year-old very low SEC Ss with a relatively simple dichotic test (e.g., dichotic syllables) in a situation which would maximize the Ss' motivational level. Until such data have been collected, the effect of rearing conditions on the rate of cerebral lateralization of function remains unclear.

SUMMARY

Six-year-old black and white Ss from low and middle socioeconomic classes (SEC) were presented a dichotic listening task composed of syllables pairs. All groups evidenced a significant right-ear advantage (REA) at recall. The magnitude of the REA did not differ as a function of race or SEC. This outcome suggests that earlier results which indicated smaller REA's for low SEC Ss, may have been due to a "floor effect" resulting from task difficulty and motivational variables.

REFERENCES

- BERLIN, C., LOWE-BELL, S., HUGHES, L., and BERLIN, H. (1972) *Dichotic right-ear advantage in males and females — ages 5-13*, paper presented at the 84th meeting of the Acoustical Society of America, Miami Beach, Fla., November.
- BROADBENT, D., and GREGORY, M. (1964) *Accuracy of recognition for speech presented to the right and left ears*, "Quart. J. Exp. Psychol.," 16, 359-360.
- BRYDEN, M. (1963) *Ear preference in auditory perception*, "J. Exp. Psychol.," 65, 103-105.
- CURRY, F., and RUTHERFORD, D. R. (1967) *Recognition and recall of dichotically presented verbal stimuli by right- and left-handed persons*, "Neuropsychologia," 5, 119-126.
- GEFFNER, D., and HOCHBERG, I. (1971) *Ear laterality performance of children from low and middle socioeconomic levels on a verbal dichotic listening task*, "Cortex," 2, 193-205.
- HALWES, T. (1969) *Effects of dichotic fusion on the perception of speech*, unpublished Ph. D. thesis, University of Minnesota (Psychology). (Issued as Supplement to Haskins Laboratories Status Report on Speech Research, September.)
- HOLLINGSHEAD, A. (1965) *Two Factor Index of Social Position*, Yale Station, New Haven, Conn.
- KIMURA, D. (1961a) *Cerebral dominance and the perception of verbal stimuli*, "Canad. J. Psychol.," 15, 166-171.
- (1961b) *Some effects of temporal-lobe damage on auditory perception*, "Canad. J. Psychol.," 15, 156-165.
- (1963) *Speech lateralization in young children as determined by an auditory test*, "J. Comp. Physiol. Psychol.," 56, 889-902.
- (1967) *Functional asymmetry of the brain in dichotic listening*, "Cortex," 3, 163-178.
- KNOX, G., and KIMURA, D. (1970) *Cerebral processing of nonverbal sounds in boys and girls*, "Neuropsychologia," 8, 227-237.
- KRASHEN, S., and HAKSHMAN, R. (1972) *Lateralization and the critical period*, "J. Acoust. Soc. Amer.," 52, 174(A).
- LENNEBERG, E. (1967) *Biological Foundations of Language*, Wiley, New York.
- MILNER, B., TAYLOR, L., and SPERRY, R. (1968) *Lateralized suppression of dichotically presented digits after commissural section in man*, "Science," 161, 184-185.
- SADICK, S. (in preparation) Doctoral dissertation, Department of Biobehavioral Sciences, University of Connecticut, Storrs.
- SHANKWEILER, D., and STUDDERT-KENNEDY, M. (1967) *Identification of consonants and vowels presented to left and right ears*, "Quart. J. Exp. Psychol.," 19, 59-65.
- STUDDERT-KENNEDY, M., and SHANKWEILER, D. (1970) *Hemispheric specialization for speech perception*, "J. Acoust. Soc. Amer.," 48, 579-594.
- (1972) *A continuum of cerebral dominance for speech perception?* "Haskins Laboratories Status Report on Speech Research" SR-31/32.