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DICHOTIC LISTENING AND DICHOTIC TEMPORAL DISCRIMINATION IN PATIENTS WITH UNILATERAL HEMISPHERE LESIONS*

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Dichotic digit listening and dichotic pure tone temporal order discrimination were administered to three experimental groups of patients with unilateral hemisphere lesions (right hemisphere lesion, left hemisphere lesion without aphasia, and left hemisphere lesion with mild aphasia) and to control group of normal subjects. In both tasks all experimental groups showed poorer performance in the ear contralateral than in the ear ipsilateral to lesion, as well as bilateral decrement in overall performance compared with control group. A lateralized complete suppression of dichotic digits was found in some of the patients in each experimental group, while no extinction of identical or non-identical pairs of pure tone was observed in any subjects. The effect of interaural time delays on temporal order judgment was significant in control and in non-aphasic left hemisphere groups, but it was not in the other groups. With respect to the nature of the stimulus, both groups of left hemisphere lesion, with and without aphasia, were inferior to the right hemisphere group in overall performance of dichotic digit listening, but not in the performance of pure tone temporal order discrimination. Multiple regression analysis revealed that about two-thirds of the total variance of ear differences to dichotic digits were explained by the side of hemispheric lesion, response bias to identical pairs of pure tone, and degrees of sensory loss. The data were discussed in terms of theoretical models for auditory information processing in normal and in brain damaged man.

It is well known that unilateral temporal lobe excision, including the transverse gyrus of Heschl, does not result in a marked defect on auditory acuity. It is also generally agreed that there are crossed and uncrossed connexions in the central auditory pathways, and that uncrossed or ipsilateral connexion from one ear to Heschl's gyrus of the same side is weaker than crossed or contralateral connexion. Bocca, Calearo, Cassinari & Migliavacca (1955) demonstrated that, in patients with temporal lobe tumors, the discrimination score for low-pass-filtered speech was much lower in the ear contralateral than in the ear ipsilateral to lesion.

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Using a Broadbent (1954)'s technique of dichotic listening, simultaneous presentation of different stimuli to the two ears (one to each ear), Kimura (1961a) also found that unilateral temporal lobectomy on either side impaired the recognition of digits arriving at the ear contralateral to the removal. Later, Goodglass and his associates called this phenomenon a "lesion effect" (Goodglass, 1967; Schulhoff & Goodglass, 1969; Sparks, Goodglass & Nickel, 1970). One more important finding of Kimura (1961b)'s study was that the speech stimuli from the right ear were more efficiently recongnized than those from the left in subjects who had speech represented in the left hemisphere, which was determined by the method of temporary inactivation of one cerebral hemisphere through the intracarotid injection of sodium amobarbital (Wada & Rasmussen, 1960). In right-handed normals, the right ear advantage is to be attributed to the left cerebral dominance for speech and to functional prepotency of the decussating pathways during dichotic verbal stimulation, presumably by inhibition in the cerebral cortex (Kimura, 1967; Studdert-Kennedy & Shankweiler, 1970).

Recent evidences that complete or near-complete suppressions of the left ear information in dichotic listening were observed in patients after section of the anterior commissure and the corpus callosum, have indicated the existence of a transcallosal pathway across to the left auditory cortex (Milner, Taylor & Sperry, 1968; Sparks & Geschwind, 1968). Damasio, Damasio, Castro-Caldas & Ferro (1976) suggested that a very poor performance referred to the left ear may be obtained by the following three cases: (1) surgical midline split of the callosum, (2) vascular sectioning of the callosum, and (3) sectioning of fibres leading to the callosum in any of the hemisphere. One-sided reporting of dichotic verbal stimuli at the left ear, which was seen in some cases of the left hemispheric lesions (Hosokawa, Sajiki, Shibuya, Kawamura *et al.*, 1976), seemed to be explained by the vascular sectioning of the auditory radiations, but not by the interhemispheric disconnexion.

Bender & Diamond (1965) related such a diminished performance at one ear to the general problem of sensory extinction. This clinical phenomenon has been mentioned since the last century, which is called auditory agnosia in original restrictive sense (see Vignolo, 1969), otherwise called auditory neglect or auditory inattention (Heilman & Valenstein, 1972; Heilman, Pandya, Karol & Geschwind, 1971). Not only an unilateral cortical lesion produces the above described ear asymmetries, but also the lesions of the brain stem cause impairment in the recognition of sounds, under simultaneous binaural stimulation. Although there is a difference between the extinction of nonverbal sounds and the suppression of verbal messages, it appears that these are to be similarly situated. The auditory hemi-inattention implies a deficient function not in an ear but in an auditory half-space, as well as visual neglect or tactile extinction.

In the present study, the effects of unilateral hemisphere lesions on the performance of dichotic digit listening (Experiment I) and of dichotic pure tone burst temporal order discrimination (Experiment II) are examined. If a verbal-nonverbal dichotomy were applied to the asymmetrical functions of the brain, the performance of the patients with right hemisphere lesions should be superior to that of the patients with left hemisphere lesions in the first task, and *vice versa* in the second task. However, evidences are available that the right hemisphere is less involved with perception of time and sequence, such as analyzing a temporal order of dichotically presented tonal sequences, than is the left hemisphere (Carmon & Nachshon, 1971; Efron, 1963; Halperin, Nachshon & Carmon, 1973; Swisher & Hirsch, 1972). We supposed that a simple auditory pattern was processed equally by the auditory areas of both hemispheres, therefore, rather the lesion effect but not the cerebral dominance effect might be important for the performance. The second purpose of the study is to elucidate the relationship between unilateral suppression of verbal materials and extinction of nonverbal materials, if they occurred. Further, based on the results from these experiments, we attempt to explore the possible factors which explain quantitatively the variation of ear differences in brain damaged populations.

Methods

Experiment I

Subjects: Sixty-nine patients, suffering from cerebrovascular disease (C.V.D.), on the rehabilitation service of Narugo Branch of Tohoku University Hospital and 13 normal control subjects participated in this investigation. Of the brain damaged patients, 26 had a lesion in the right hemisphere (RHL), 27 had a left hemisphere lesion without aphasia (LHL−) and 16 had a left hemisphere lesion with mild aphasia (LHL+). All patients were right-handed and had unilateral lesions as documented by clinical symptomatology and the results of at least one ancillary diagnostic procedure, such as EEG, angiography or cerebral computed tomography. The control subjects were also right-handed, and showed no evidence or history of cerebral disease, head injury or epilepsy. Subjects were excluded from the study who (a) were left-handed or ambidextrous, (b) had a past history or clinical picture pointing to involvement of both hemispheres, (c) could not be given the test because of poor physical or mental ability, (d) had a history of psychiatric disorder or mental deficiency, (e) had a hearing loss over 20 dB SPL for the frequencies of 500, 1000, and 2000 Hz or had an average between-ear difference of greater than 10 dB, (f) had participated in dichotic research before and were not naive with reference to the study. Aphasic patients were screened by the language examination in our clinic, including a 39-item version of the Token Test and Scheull-Sasanuma's Test for Aphasia. Background information of each group of subjects is summarized in Table 1. All groups were not significantly different with respect to age, post-onset-months (in experimental groups), and the weighed score of the Digit-span subtest of the W.A.I.S. (but LHL+ was significantly inferior to the cotrol group).

Stimulus materials: A tape was prepared consisting of 3 sets of lists, each set comprising 4 pairs of 2 different lists of each length ranging from 1 to 3 digits. The stimulus lists were constructed from numbers 1–9 and no number appeared more than

Table 1. Background information of each group in Experiment I.

Information	Groups			
	RHL	LHL −	LHL +	control
Number of subjects	26(13)†	27(10)	16(7)	13(8)
Age in years	53.7(52.2)	54.0(53.2)	49.2(46.9)	51.7(49.0)
Digit span of the WAIS (weighted score)	8.3(7.8)	8.2(8.2)	7.0(6.2)	9.8(10.6)
Post-onset-months	10.3(10.8)	8.4(11.5)	10.2(9.4)	——
Types of C.V.D.				
Infarction	16(7)	22(8)	9(4)	
Hemorrhage	10(6)	4(2)	6(3)	
AV malformation	0(0)	1(0)	1(0)	

† The data of each group in Experiment II is given in parentheses. (Note: Each group in Experiment II consisted of a part of the corresponding group in Experiment I.)

once in the same list. Recording was carried out on a SONY TC–777S-2J stereophonic tape recorder so that, on each trial, subjects received 2 lists of digits simultaneously, one to each ear. All lists were pronounced by a female speaker with even intensity and uniform pitch contour. Onset of dichotic stimuli was synchronized within 20 msec, as checked by a dual channel oscilloscope, and the duration of each stimulus varied from 210–460 msec. A voicing feature of the initial phoneme was not controlled, so the voice-unvoiced combinations occurred. Presentation rate was one digit pair per two-thirds of a second.

Procedure: Subjects were tested individually in a sound reduction room, and were introduced to the material by monaurally presenting Digit-span subtest of the W.A.I.S. No difficulty was experienced in identifying and recalling at least 3-digits, then the subject was instructed that he would receive two lists of digit simultaneously, a different digit to each ear, and that his task was to recall and to write down on his answer sheet as many of the numbers as he could remember after each pair of lists, irrespective of order. If he remembered just one list or part of lists, he was still to write on the side where it was heard. There were 4 of each length of span with from 1 to 3 digits per half-span. The dichotic digits were presented to subjects, with an average intensity approximately 30 dB above sensation level for each ear, using a TEAC A–2300–2T stereophonic tape recorder fed through a RION AA–36A dual channel audiometer and coupled to matched earphones (RION). Subjects were allowed as much time as necessary to respond to each dichotic presentation. After trial runs were made, a total of 24 digits were given in the same order to each ear of each subject. The time required for completing the testing was about 20 minutes. The scores used were the percent correct response for each ear.

Experiment II

Subjects: Thirty-eight of the previous subjects were employed — 13 patients from the group RHL, 10 from LHL+, 7 from LHL+, and 8 from the control group. These subjects were selected on the basis of their availability and willingness to participate as subjects in this experiment. Each of the new groups was not significantly different from the corresponding group of the first experiment, as well as from one another, with respect to age, score of Digit-span, and, in experimetnal groups, post-onset-months. (In the same way as in Experiment I, the group LHL+ was significantly inferior in performance of Digit-span to the control group.) These data are presented in Table 1, shown in parentheses.

Stimulus materials: Two 50 msec pure tone bursts at 1500 Hz, having rise-decay time of 10 msec, were used as binaural test stimuli. These tone bursts were presented to subjects as simultaneously dichotic and dichotic with interaural time delay(Δt)s of 25, 50, 75, 100, 125 and 150 msec. The duration and rise-decay time of each tone burst and interaural temporal separation were controlled by a digital pulse generator and two channel electronic switch system (RION SB–04). Tape preparation involved the use of a TEAC A–2300–2T stereophonic tape recroder. Stimulus tape was symmetrically constructed; *e.g.*, for every pair with $\Delta t=25$ msec ($\Delta t>0$ when the channel 1 leads), there was another pair with $\Delta t=-25$ msec ($\Delta t<0$ when the channel 2 leads). The 1 kHz calibration tone was inserted at the beginning of the tape.

Procedure: A few days after the administration of the dichotic digit task, the subject was tested again in a sound reduction room. Prior to the experiment the monaural threshold of each subject was measured again by the method of limits. The subject was then instructed that he would receive two stimuli at the two ears, and that he was to indicate by gestural (pointing) response which stimulus occurred first. If he heard just one stimulus, he was still to indicate the side corresponding to the ear at which the single stimulus appeared. The subject was allowed to respond by saying that the onset time difference of two stimuli was indiscriminable or it was perceived as equally obvious. Before entering the test period, trial runs were made 10 times each at the interaural time delays of 50, 100, and 200 msec, under both the conditions of channel 1 leading and channel 2 leading. The stimulus tape was presented to subject via a TEAC A-2300-2T stereophonic tape recorder coupled to a RION AA–36A audiometer through a matched set of earphones (RION). Intertrial intervals were 10 msec. Stimulus intensity at each ear was set at 30 dB re monaural threshold. A total of 130 trials were delivered during a single session, lasting for approximately 40 minutes, without removing the earphones.

Results

Experiment I

Mean percent correct ear scores for each group are presented in Table 2. The ear asymmetries reflected in the group means constructed two patterns. Right hemisphere group, as well as control group, showed a right ear superiority in response to the dichotic digits. On the other hand, both aphasic and non-aphasic left hemisphere groups showed

Table 2. Mean percent correct score by ear in each group.

	Groups			
	RHL (N=26)	LHL − (N=27)	LHL + (N=16)	control (N=13)
Percent correct				
Right ear	84.5±16.9	48.0±28.3	29.9±23.1	74.0±8.6
Left ear	27.6±24.3	54.0±29.3	61.5±25.8	70.2±6.9
t-value of				
Ear differences	8.65**	0.66	2.73*	1.38

* $p<0.05$, ** $p<0.001$

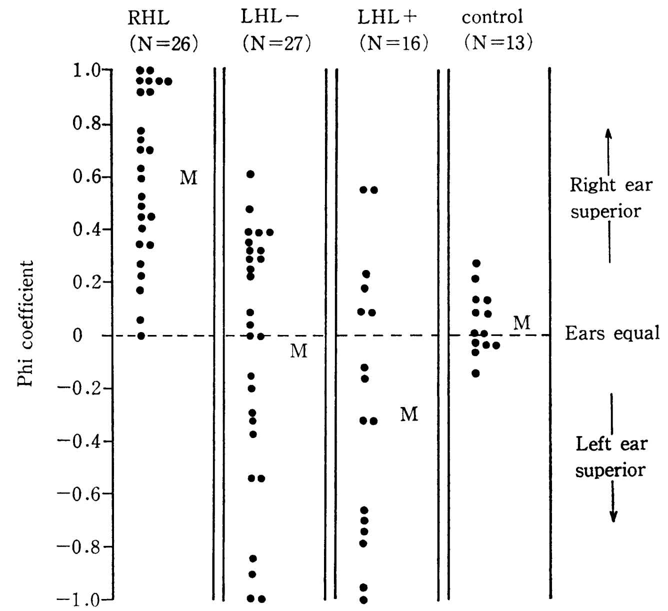

Fig. 1. Distribution of phi coefficients for dichotic digit performance in each group. The mean phi coefficients (M) of the grop RHL, LHL−, LHL+, and control are 0.597 (SD=0.312), −0.066 (SD=0.484), −0.318 (SD=0.463), and 0.045 (SD=0.119), respectively. See text for full explanation.

a left ear superiority. Application of t-tests revealed the significant differences between ears in RHL (t=8.65, $p<0.001$) and in LHL+(t=2.73, $p<0.05$). The control group's slight right ear advantage, as expected from the predominance of the left hemisphere for speech, however, did not reach the 0.05 level of confidence.

With respect to total accuracy for both ears pooled, the performance of the control group was significantly better than that of each experimental group, the respective t-values being 4.25, 4.39, and 9.12 for RHL, LHL−, and LHL+. There were no significant differences among the experimental groups, but the difference between the performances of RHL and LHL+ was significant (t=2.93, $p<0.01$).

Fig. 1 shows the distribution of the phi correlation coefficients of the experimental and the control subjects for a comparison of individual performances. The phi coefficient, an index of ear differences in dichotic listening (Kuhn, 1973), may vary from -1 to +1: negative value indicates a left ear superiority and positive value indicates a right ear superiority. It can be seen from Fig. 1 that all the RHL patients but one exhibit an inferiority of report in the ear contralateral to lesion. In contrast, the indices are much more scattered in both of the left hemisphere groups, ranging from nearby 0.6 to -1.0. It should be noted that less than 41 percent of the LHL— patients show a left ear advantage while more than 69 percent of the LHL+ patients show it, although these two groups give the same direction of their mean phi coefficients. It should also be emphasized that complete or near complete suppression of one ear or the other to the dichotic digits occurs only in the ear opposite to the damage, regardless of damaged hemisphere. No such extreme cases were found, of course, in the control group. These results were summarized in Table 3. In experimental groups, the incidence of the case, who manifested a lateralized complete suppression (which does not always mean to imply the phi coefficient to be either -1 or +1) was about 14 percent, as a whole. Number of patients who showed a suppression without marked decreasing of total accuracy was distributed almost equally in each experimental group.

Table 3. Numbers of inferior performance in ipsilateral and contralateral ear to lesion for dichotic digits ($N=69$).

Groups	N	Side of inferior ear		
		Contralateral	Ipsilsteral	Ears equal
RHL	26	25(4)†	0(0)	1
LHL −	27	11(4)	14(0)	2
LHL +	16	11(2)	5(0)	0
Total	69	47(10)	19(0)	3

† Number of patients who exhibited a complete suppression in either ear is given in parentheses.

Further analysis was carried out to explore this phenomenon of contralateral ear suppression, by combining left and right hemisphere cases. A group of 10 patients with suppression was slightly inferior to the other group of 59 patients without suppression in total accuracy of performance, but it was not significant: mean percent correct scores of suppression group was 45.8, while that of non-suppression group was 52.7 ($t=1.44$). There were also no significant differences between the two groups with respect to age (means of 50.7 vs. 53.1 years for suppression and non-suppression groups, respectively), and post-onset-months (10.5 vs. 9.4 months). Significant difference was found in their results of clinical sensory examination: moderate to severe sensory loss was detected in 8 of 10 patients with suppression and in 22 of 59 patients without suppression (*chi*-square=7.21, $p<0.05$). Concerning other neurological signs, such

Table 4. Comparison of clinical neurological signs between the patients with and without a lateralized complete suppression for dichotic digits.

	N	Unilateral spatial neglect		Hemianopsia		Sensory loss	
		+	−	+	−	++	±
With suppression	10	2	8	4	6	8	2
Without suppression	59	4	55	4	55	22	37
chi-square		0.585		1.155		7.218*	

* $p<0.05$
Legend: + = present, − = absent, ++ = moderate to severe defect, ± = absent or mild defect.

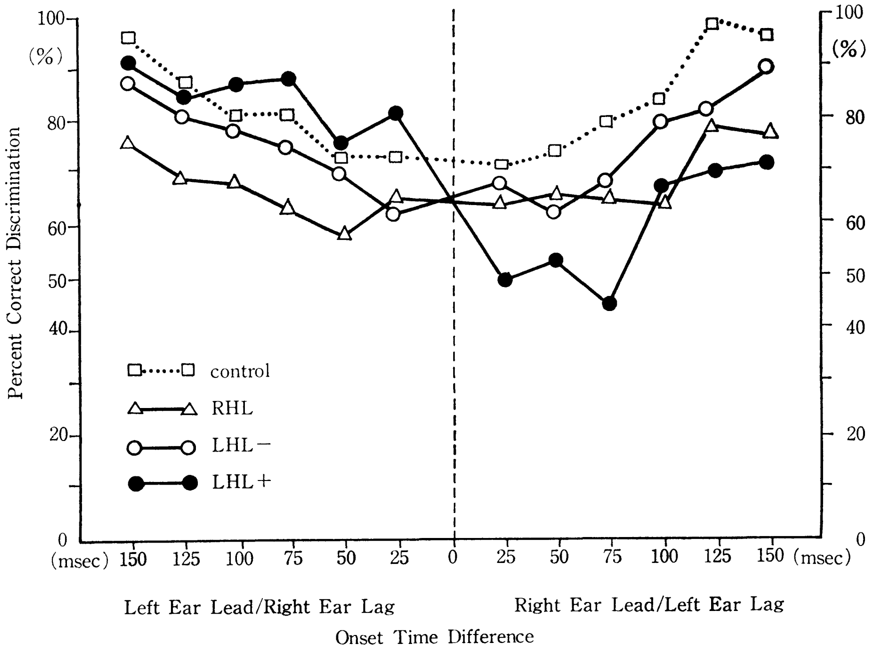

Fig. 2. Percent correct discrimination is plotted on the ordinate as a function of the dichotic temporal interval separating the transient stimuli (±t) on the abscissa. Average data of each group are shown.

as unilateral spatial neglect or hemianopsia, however, no significant differences were observed (see Table 4).

Experiment II

The data of percent correct discrimination, for each group, in each interaural temporal interval (or interaural time delay; Δt) are illustrated graphically in Fig. 2. The trends of LHL− and control group appear to be similar: the performance level increased at longer Δts, while it decreased at shorter Δts, regardless of the sign of the Δt. By contrast, such an effect seems to be obscure in RHL and LHL+.

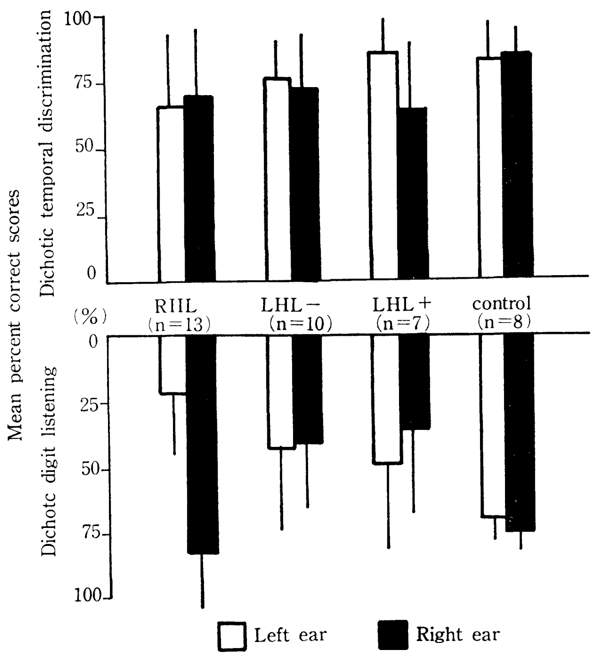

Fig. 3. Mean percent correct ear scores comparing between dichotic digit listening and dichotic temporal order discrimination. See text for full explanation.

Two way analysis of variance of the pure tone temporal order discrimination showed that the main effect of dichotic temporal interval (Δt) was highly significant in LHL− ($F=15.48$, $df=1/5$, $p<0.005$) and in control group ($F=14.88$, $df=5/5$, $p<0.01$). In RHL and LHL+, the main effect of Δt was not nearly significant. Another main effect of ear difference was highly significant only in LHL+ ($F=34.06$, $df=1/5$, $p<0.005$), but it was not significant in the other groups.

Fig. 3 provides a comparison of mean percent correct right and left ear scores of each group on the two different auditory tasks: one is a verbal task in which the subject received dichotic digits and was required to respond by writing what he had heard in each ear, the other is a nonverbal task in which the subject received two successive pure tones either identical or nonidentical and was required to respond by pointing as to which ear received the first stimulus. It was revealed (1) that in the digit task, a significant difference between ears was found in RHL ($t=6.74$, $p<0.001$), but not in the other groups, (2) that in the pure tone task, there were no significant differences between ears in all groups, (3) that RHL showed a striking right ear superiority in the digit task by contrast with an almost equal performance of each ear in the pure tone task, and (4) that LHL− and LHL+, on the other hand, showed a left ear superiority in the two tasks, but the ear differences appeared to be more remarkable in LHL+ than in LHL−.

Another finding of interest is that no lateralized extinction of pure tones, whether identical or nonidentical pairs, was observed in any subjects, even in the patients who had shown unilateral suppression of dichotic digits. Product moment correlation coefficient between the phi coefficients of dichotic digit listening and of dichotic temporal order discrimination was not high ($r=0.189$). However, the ear contralateral to lesion appeared to be more unresponsive to identical pairs of pure tone ($\Delta t=0$) as compared with the ear ipsilateral in all the experimental groups. Therefore, we made another index for measuring such tendency, which we proposed to call "ear biased ratio". It is easily to be calculated in the following way;

$$\text{Ear biased ratio} = (\text{L}-\text{R})/\text{T}$$

where

L=number of left ear responses by ignoring right ear stimulus,
R=number of right ear responses by ignoring left ear stimulus,
T=total number of identical pairs.

Thus, we can obtain the significant correlation coefficient between the phi coefficient and the ear biased ratio, within the experimental groups ($r=0.654$, $p<0.001$). Concerning overall performance of pure tone task (both identical and nonidentical pairs), patterns of the ear differences in each experimental group were not simple (see Table 5).

In order to ascertain the source of the variation of the phi coefficient, which indicates the magnitude and the direction of ear differences in dichotic digit performance, a multiple regression analysis was carried out with the phi coefficient as the dependent variable and with the following independent variables: age (in years), post-onset-months, Digit-span of the W.A.I.S. (in weighed score), right-left discrepancy of hearing loss in pure tone audiometry (in dB), side of hemispheric lesion (left=0, right=1), aphasia (absent=0, present=1), hemianopsia (absent=0, present=1), degrees of sensory loss (absent=0, mild loss=1, moderate to severe loss=2), and the ear biased ratio in judgment of identical pairs of pure tone. Although our sample was small (30 patients), relationship of factors were examined in this regard. The analysis has been performed in a stepwise fashion, by selecting for entry at each step among the set of possible variables the variable with the highest F-value. The procedure was stopped when no

Table 5. Changing patterns of inferior ear between digit and pure tone tasks in each experimental group ($N=29$†).

Inferior ear to reprot		Groups			
Recognition of dichotic digits	Discrimination of temporal order for pure tones	RHL ($N=13$)	LHL − ($N=9$)	LHL + ($N=7$)	Total ($N=29$)
Ipsilateral	→ Ipsilateral	0	1	1	2
Ipsilateral	→ Contralateral	0	4	1	5
Contralateral	→ Ipsilateral	8	3	1	12
Contralateral	→ Contralateral	5	1	4	10

† Excluding a patient who did not show an ear asymmetry in dichotic digit listening.

Table 6. Multiple linear regression of clinical characteristics of patiens on the phi coefficient of dichotic digit performance—total group of patients ($N=30$).

Regressors	Regression coefficient	t-value	Variance explained alone
Side of lesion[1]	−0.563	3.913**	0.434
Ear biased ratio[2]	0.512	3.722**	0.163
Sensory loss[3]	−0.180	2.195*	0.056
Post-onset-months	0.014	1.381	0.019
Age	0.009	1.288	0.021
	Intercept costant=0.135		
	Multiple correlation coefficient $R=0.833$ Percentage total variance explained $100R^2=69.3$		

* $p<0.05$, ** $p<0.01$

1) Coded as: 1=right hemisphere lesion, 2=left hemisphere lesion.
2) See text for definition.
3) Coded from 0–2: 0=absent (normal), 1=mild defect, 2=moderate to severe defect.

Table 7. Analysis of variance for multiple linear regression.

Source of variation	Degrees of freedom	Sum of squares	Mean of squares	F-value
Regression	5	6.593	1.319	10.857*
Residual	24	2.915	0.121	
Total	29	9.508		

* $p<0.05$

further factor was found with partial F-value of 1.0. The results of this analysis are summarized in Table 6 and 7. As shown in Table 6, five variables were added to the regression equation. Side of lesion is strongly related to the variation of phi coefficient, which explains more than 43 percent of the variance. It is reasonable that the direction of phi coefficient may be determined to a great extent by the side of hemispheric lesion (or poor performance in the ear contralateral to lesion). Ear biased ratio and the degrees of sensory loss explain about 16 and 5 percent of the variance, respectively. It may be thought that the former indicates a latent auditory agnosia or rather an inattention to the half-field opposite to the damage, while the latter indicates an existence of a deep lesion. The regression coefficients for these three factors were significantly different from zero, but the coefficients for post-onset-months and for age were not. The five factors combined explain about 69 percent of the total variance ($F=10.85$, $df=5/29$, $p<0.05$).

Discussion

Right-handed normal subjects showed, as expected, a right ear superiority over left for dichotically presented digits. By contrast, the patients with unilateral hemisphere lesions, regardless of the side affected, reported more accurately in the ear ipsilateral than in the ear contralateral to lesion for the same stimuli. This confirms the findings of the lesion effect as a main source of variation of ear asymmetries in brain damaged patients (Goodglass, 1967; Schulhoff & Goodglass, 1969; Sparks, Goodglass & Nickel, 1970). However, a large scatter of individual results was observed especially in both groups of the patients with left hemisphere lesions, although each group performance showed uniformly a contralateral ear disadvantage. We thought that there might be some interactions between the lesion effect and the cerebral dominance effect in determining the ear asymmetry, because a number of the non-aphasic patients with left hemisphere lesions, even a few of the aphasic patients, still showed a right ear superiority in spite of the lesion effect. In addition, a consistent right ear superiority that was demonstrated by the patients with right hemisphere lesions could be due to a double advantage of both effects.

On the task of dichotic pure tone time-ordering, the normal subjects had no advantages in either ear. A left ear superiority shown by the left hemisphere groups seemed to be slightly apparent in the second task as compared with the first task, while a right ear superiority shown by the right hemisphere group was much more remarkable in the first than in the second task. It was revealed that the right hemisphere group was most impaired among of all. These results contradict traditional hypothesis that temporal characteristics of the stimuli are mediated by the left hemisphere (Efron, 1963). However, it can not be concluded that temporal characteristics of the stimuli are mediated by the right hemisphere, because of only a small difference detected between the performance of the right hemisphere group and that of the aphasic group. Berlin, Lowe-Bell, Jannetta & Kline (1972) suggested that the function of some preliminary acoustic analysis, such as a simple auditory time-ordering, might be lost by temporal lobe excision in either hemisphere. We thought that the central processing of dichotic stimuli would depend on the nature of the stimulus, but not on the temporal characteristics of the stimuli, in patients with unilateral hemisphere lesions.

Efron, Bogen & Yund (1977) found that although the suppressin may occur for dichotic speech in commissurotomized patients, it is not present for dichotically presented pure tones (dichotic chord). Similarly, we also found that there were no cases who manifested a lateralized extinction for pure tones, either of identical or of nonidentical pairs, even in the patients with contralateral ear suppression for dichotic digits. It is probable that these two phenomena, verbal suppression and nonverbal extinction, are controlled by the different mechanisms; the former means to imply an extreme case of ear asymmetry reflecting the cerebral dominance and the lesion effects, while the latter may indicate a defect or an inattention in the half-field opposite to the damage reflecting the lesion effect alone. We re-emphasize that a simple auditory pattern is thought to be processed equally by the auditory areas of both hemispheres.

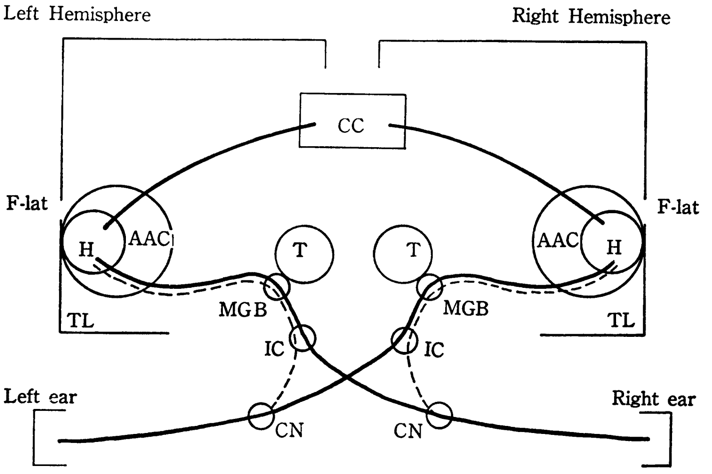

Fig. 4. Schematic representation of the auditory pathways. AAC: auditory association cortex, CC: corpus callosum, CN: cochlear nucleus, F-lat: Fissure-lateral (Sylvian), H: transverse gyrus of Heschl (primary auditory cortex), IC: inferior colliculus, MGB: medial geniculate body, T: thalamus, TL: temporal lobe.

It can be said that the lesion effect comes into play in both tasks, but the cerebral dominance effect reveals itself at the level of word recognition but not at the preliminary level.

Referring to Figure 4, which represented a model patterned after Sparks, Goodglass & Nickel (1970), we exmaine the results of ear asymmetry and of verbal suppression. Right ear advantage for verbal materials as seen in the normal and the right hemisphere groups can be explained by thinking that the ipsilateral pathways are inhibited by the contralateral during dichotic presentation, and that the left hemisphere, where the speech signals should be finally processed, remains intact in both groups. Another right ear superiority shown by some cases of the left hemisphere groups may be accounted for by a vascular sectioning of fibres, led from the right hemisphere through the transcallosal pathways, within the left hemisphere. Left ear advantage shown by the other members of the left hemisphere groups can be interpreted by a lesion of the auditory radiations from the medial geniculate body to the Heschl's gyrus of the left temporal lobe. It is improbable to presume a deep lesion including the corpus callosum in our patients with cerebrovascular disease. However, further examination will be required in this regard.

According to Kinsbourne (1970), an injured hemisphere may produce a generalized diminution of attention in its contralateral field. This is a noticeable explanation for the lesion effect. Our previous study on visual perception in patients with unilateral hemisphere lesions (Hosokawa, Isagoda & Shibuya, 1977) has shown such a tendency — contralateral field inferiority. Present study also demonstrates the same tendency, as a main determinant of ear asymmetry in dichotic listening tasks. It is suggested that the cerebral dominance for verbal and for nonverbal materials may play its role at a higher level of performance.

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