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THE LEFT HEMISPHERE'S INABILITY TO SUSTAIN ATTENTION OVER EXTENDED TIME PERIODS IN SCHIZOPHRENICS

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Abstract

Each hemisphere's ability to sustain attention over extended time periods was investigated in 14 schizophrenics utilizing dichotic detection tasks. Schizophrenics produced significantly higher rates of omission errors as compared to commission errors. As the sessions progressed, the rates of omission errors for schizophrenics fluctuated markedly, while the rates of commission errors remained constant. Primarily due to the fluctuation of omission errors, the detection index over progressive sessions decreased when schizophrenics were engaged in right-ear tasks. These results suggest that schizophrenics demonstrate a deficit concerning "response set" in the left hemisphere.

Introduction

Some recent neuropsychological investigations of schizophrenics have shown that they demonstrate a dysfunction of the left hemisphere (Colbourn & Lishman, 1979; Flor-Henry, 1976: Gruzelier & Hammond, 1976; Gur, 1978; Hammond & Gruzelier, 1978). Others have shown that they demonstrate a disintegration in both hemispheres (Beaumont & Dimond, 1973; Carr, 1980; Green, 1978). These studies have revealed new facets concerning the performance deficits of schizophrenics.

In addition, disturbances in attentional functioning have long been cited as fundamental defects of schizophrenics. These disturbances are thought to have some influence on the results of neuropsychological tests. However, few previous neuropsychological investigations of schizophrenics have been conducted with the intention of clarifying the role that these disturbances play on the test results.

In hope of clarifying this role, the present study was conducted to investigate attentional functioning of each hemisphere in schizophrenics, especially the hemisphere's ability to sustain attention over an extended time period. Previous studies have already pointed out that schizophrenics have disabilities in sustaining attention (Orzack & Kornetsky, 1966; Rappaport, Hopkins, Silverman & Hall, 1972; Sphon, Lacoursiere, Thompson & Coyne, 1977; Wholberg & Kornetsky, 1973).

In this study, schizophrenics were required to perform auditory vigilance tasks utilizing one hemisphere under dichotic listening conditions.

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Method

Subjects

Subjects consisted of randomly selected schizophrenic patients (6 males, 8 females) under treatment at the Neuropsychiatric Outpatient Clinic, University of Tokyo Hospital. All patients met the diagnostic criteria of DSM-III (American Psychiatric Association, 1980). Their ages ranged from 23 to 52 years (mean age, 35.7; S.D., 7.9), and all patients had been engaged in psychotropic drug therapy. Seventeen normal subjects (11 males, 6 females), consisting of drug company employees, hospital staff, and university students with no history of psychiatric or neurological disease, comprised the control group. Their ages ranged from 19 to 60 years (mean age, 34.6; S.D., 9.7). All subjects were right handed.

Procedure

As previously mentioned, the purpose of this study was to examine each cerebral hemisphere's ability to sustain attention. To achieve this purpose, a dichotic detection task was employed in this study; that is, participants were required to listen to dichotically-presented non-verbal sounds through a pair of headphones and to press a response key upon detection of a particular target sound presented to one ear.

The stimuli consisted of four non-verbal sounds, which are shown schematically in Fig. 1. Each stimulus consisted of a frequency-modulated sound which lasted 50 msec and a frequency constant sound which lasted 100 msec, yielding a total duration time of 150 msec. The four stimuli were paired using the basis of equal constant frequency. Each pair of stimuli was presented to each ear during a session. Two sounds in the upper part of Fig. 1 were presented more frequently, with a priori probability of .7, than the two sounds in the lower part, with a priori probability of .3. Infrequent stimulus of each pair, with a constant frequency of 1 kHz (lower left part of Fig. 1), was to be detected, that being the "target stimulus". Interstimulus intervals were of 2 sec duration, with tone intensities approximating 50 dBSL. The total number of stimuli for one session was 200. A total of 10 sessions, 5 for each ear, was completed for each subject, with sidedness of the target-detecting ear (attending ear) being alternated for each successive session. The attended ear for the first session was also alternated subject by subject. Intersession intervals were of 5 min duration. In this experiment, the participants were asked to wear eye masks so as to eliminate visual stimuli. The finger for pressing the response key was the index finger of the hand homolateral to the attended ear.

Results

1) Omission and Commission Errors for Both Diagnostic Groups

Schizophrenics, as opposed to normal controls, displayed far more marked intra-individual fluctuations in the rate of omission errors as the sessions progressed. The rate of omission errors in schizophrenics tended to increase over progressive sessions, especially when engaged in right-ear tasks. The rate of commission errors, however, remained rather constant over progressive sessions in schizophrenics as

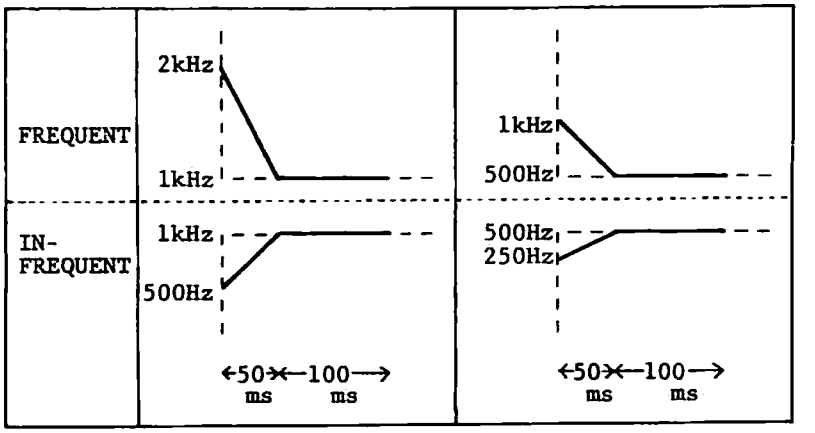

Fig. 1 *Schemata of stimuli. See text for explanation.*

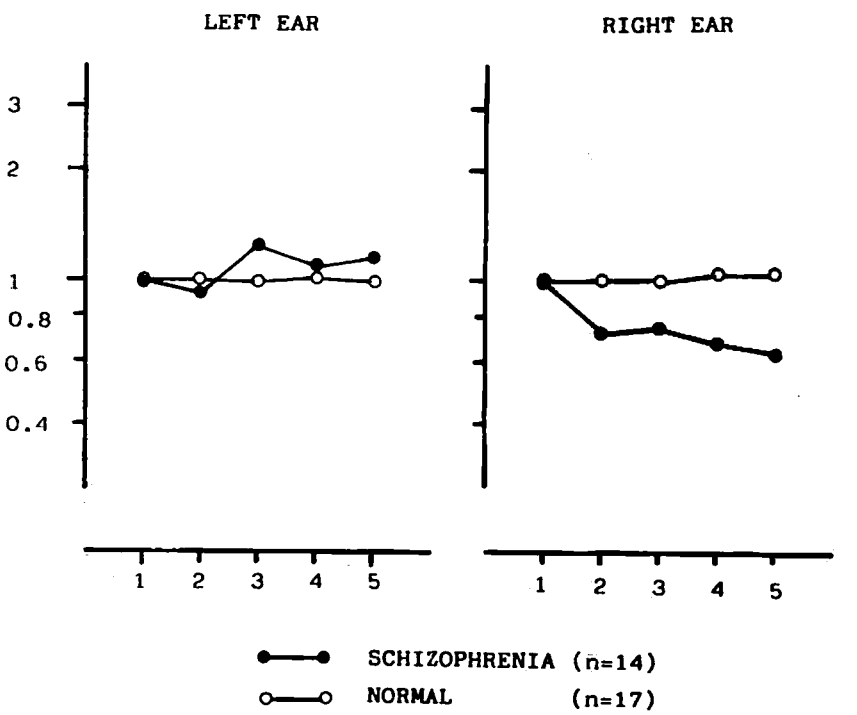

Fig. 2 *Mean ratio for the detection index for each diagnostic group. The abscissa indicates the session, and the ordinate indicates the ratio. Note that the ordinate is in logarithmic scale. See text for further explanation.*

		SESSIONS				
		1	2	3	4	5
OMISSION ERRORS(%)						
SCHIZOPHRENICS (n=14)	RIGHT EAR	24.8 ± 19.9	36.0 ± 24.0	34.3 ± 26.4	39.4 ± 25.5	38.9 ± 24.8
	LEFT EAR	31.4 ± 23.7	34.5 ± 28.0	31.7 ± 24.9	35.4 ± 29.3	36.4 ± 24.9
NORMAL CONTROLS (n=17)	RIGHT EAR	7.0 ± 9.0	10.1 ± 13.3	7.9 ± 10.3	5.9 ± 8.8	6.7 ± 7.4
	LEFT EAR	8.7 ± 10.6	8.7 ± 10.3	10.2 ± 15.7	10.1 ± 14.1	10.9 ± 13.8
COMMISSION ERRORS(%)						
SCHIZOPHRENICS (n=14)	RIGHT EAR	10.3 ± 10.5	10.3 ± 10.8	11.5 ± 12.8	10.8 ± 12.5	11.1 ± 11.1
	LEFT EAR	7.8 ± 10.9	7.9 ± 11.5	6.3 ± 9.4	7.3 ± 9.3	7.3 ± 9.2
NORMAL CONTROLS (n=17)	RIGHT EAR	3.9 ± 6.6	2.9 ± 8.0	2.5 ± 4.4	2.3 ± 6.3	3.1 ± 5.6
	LEFT EAR	4.7 ± 7.3	3.9 ± 8.1	3.1 ± 7.4	3.7 ± 6.7	3.3 ± 7.3
DETECTION INDEX						
SCHIZOPHRENICS (n=14)	RIGHT EAR	64.9 ± 25.5	53.7 ± 31.4	54.2 ± 34.4	49.8 ± 32.9	50.0 ± 33.0
	LEFT EAR	60.8 ± 28.3	57.6 ± 34.5	62.1 ± 30.6	57.3 ± 34.8	56.2 ± 30.2
NORMAL CONTROLS (n=17)	RIGHT EAR	89.1 ± 13.6	87.0 ± 16.9	89.5 ± 12.2	91.8 ± 13.2	90.2 ± 10.9
	LEFT EAR	86.6 ± 17.3	87.4 ± 24.2	86.8 ± 22.6	86.2 ± 20.5	85.8 ± 19.9
REACTION TIME(msec)						
SCHIZOPHRENICS (n=14)	RIGHT EAR	611 ± 153	643 ± 145	633 ± 148	644 ± 158	645 ± 167
	LEFT EAR	645 ± 161	633 ± 143	604 ± 143	614 ± 120	632 ± 126
NORMAL CONTROLS (n=17)	RIGHT EAR	478 ± 94	513 ± 120	495 ± 115	494 ± 111	496 ± 91
	LEFT EAR	492 ± 95	487 ± 87	477 ± 95	505 ± 103	493 ± 103

Table 1 *Omission errors, commission errors, detection index and reaction time for each diagnostic group, ear task, and session. Right (left) ear indicates right-(left-) ear task, respectively.*

well as normal controls. The mean rates and standard deviations of omission and commission errors for each session and diagnostic group are shown in Table 1. The results of analysis of variance (ANOVA) revealed that the rate of omission errors, as well as commission errors, in schizophrenics was significantly higher than that of the normal controls (omission errors: $F(1, 290) = 134.811$, $p < .001$: commission errors: $F(1, 290) = 31.673$, $p < .001$). These results also revealed that schizophrenics displayed a higher rate of commission errors when engaged in right-ear tasks, as opposed to left-ear tasks ($F(1, 290) = 4.403$, $p < .035$).

2) Detection Indexes (DIs) for Both Diagnostic Groups

The detection index (Brown & Hopkins, 1967) for each subject and session was calculated according to the following formula:

$$DI = ((V - Om) \times 100/V) - (Co \times 100/W),$$

where V = total number of target stimuli; Om = number of omission errors; Co = number of commission errors; W = total number of non-target stimuli. The means and standard deviations of the detection indexes for each session and diagnostic group are shown in Table 1. The results of the analysis of variance (ANOVA) revealed that schizophrenics displayed significantly lower values in the detection index as compared to normal controls ($F(1, 290) = 121.291$, $p < .001$). In order to clarify the intra-individual fluctuation of the detection index over progressive sessions, the ratio of the detection index for each session was calculated using "1" as the value of the first session for the task for each ear. The mean ratio for each session and diagnostic group is plotted in Fig. 2. The results of analysis of variance (ANOVA) revealed that in the case of schizophrenics, the ratio of the detection index for right-ear tasks was significantly lower than that for left-ear tasks ($F(1, 290) = 13.782$, $p < .001$). When the ratios of the detection index were compared between the left and right-ear tasks, session for session, significant differences in the ratio of the detection index between left and right-ear tasks were found during the 3rd, 4th and 5th sessions. Specifically, the ratio for the right-ear tasks was lower than that for the left-ear tasks (3rd session: $F(1, 58) = 4.000$, $p < .048$; 4th session: $F(1, 58) = 3.742$, $p < .055$; 5th session: $F(1, 58) = 4.525$, $p < .036$).

3) Reaction Time for Both Diagnostic Groups

The reaction time for the correct responses to the target stimuli remained rather constant over progressive sessions in schizophrenics as well as normal controls. The mean reaction time and standard deviation for each session and diagnostic group is shown in Table 1. The results of analysis of variance (ANOVA) revealed that schizophrenics' reaction time was significantly slower than that of normal controls ($F(1, 290) = 93.985$, $p < .001$). The mean reaction time through the five sessions for the task for each ear was as follows; schizophrenics, right-ear task: 635 msec; left-ear task: 626 msec; normal controls, right-ear task: 495 msec; left-ear task: 491 msec.

Discussion

Many studies have been done on schizophrenics' performance in vigilance tasks (Hammond & Gruzelier, 1978; Mirsky & Kornetsky, 1964; Rappaport, Hopkins, Silverman & Hall, 1972; Wohlberg & Kornetsky, 1973). The results of these studies are consistent with each other in that schizophrenics demonstrate fewer commission errors than omission errors, and that the commission errors in schizophrenics remain constant during the experimental period. As Hammond & Gruzelier (1978) have suggested, these results seem to reflect a deficit in either the response selection or response organization process. If there were more significant disturbances in the stimulus analysis process, then one would expect a marked increase in commission errors, too. In addition, the results of this study suggest that schizophrenics' deficits in the response selection or response organization process, namely, Broadbent's "response set" (1971), become greater over an extended time period, especially when they are engaged in right-ear tasks (that is, left-hemisphere tasks). Pribram & McGuinness (1975) have assumed that activation, which is defined in terms of tonic physiological readiness to respond, is controlled by the basal ganglia of the forebrain. Disturbances of this system in schizophrenics, especially in the left hemisphere, may provide a neural basis for the behaviorally observable deficit in the response set, especially when schizophrenics are engaged in left-hemisphere tasks.

It should be noticed that the fact that in this study schizophrenics demonstrated more commission errors for right-ear tasks than left-ear tasks may indicate that disturbances in the stimulus analysis process in schizophrenics are also more pronounced in the left hemisphere than in the right.

Based upon the results of this study, it is reasonable to assume that disturbances in the response selection or response organization process in schizophrenics are more evident than in the stimulus analysis process. This assumption does not rule out the possibility of individual differences in disturbance patterns.

The above results seem to lend support to the hypothesis of left hemisphere dysfunction in schizophrenics (Colbourn & Lishman, 1979; Flor-Henry, 1976; Gruzelier & Hammond, 1976; Gur, 1978; Hammond & Gruzelier, 1978). However, Dimond (1976) has suggested, on the basis of his experiment employing split-brain patients, that each hemisphere has its own vigilance system, and that the left hemisphere tends to show a rapid decrease in performance level while the right hemisphere maintains a constant performance level. He has also suggested that the integration mechanism for both hemispheres plays an important role in attentional functioning. According to Dimond, the results of this study suggest that there may be some disturbances in the integration mechanism of both hemispheres in schizophrenics, as has already been pointed out by other investigators (Dimond & Beaumont, 1973; Carr, 1980; Green, 1978), and that these disturbances may reveal the characteristics of the left hemisphere's inability to sustain an initial performance level.

As is shown in the results of this study, schizophrenics' reaction time for correct responses was slower than that of normal controls. However, reaction time remained rather constant, even when the number of omission errors increased. This fact indicates that disturbances in the response set are not directly reflected in the slowness of reaction time for correct responses in schizophrenics. Hence, further research is needed to investigate the genesis of slow reaction time in schizophrenics.

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