Brit. J. Psychiat. (1983), **142**, 477–481

Left Hemisphere's Inability to Sustain Attention over Extended Time Periods in Schizophrenics

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Summary: Each hemisphere's ability to sustain attention over extended time periods was investigated in 14 schizophrenics and 17 controls using dichotic detection tasks. Schizophrenics produced significantly higher rates of omission errors, as compared to that of commission errors. The rates of omission errors for schizophrenics fluctuated markedly, while the rates of commission errors remained fairly constant. Primarily due to the fluctuation of omission errors, the detection index decreased progressively when schizophrenics were engaged in right-ear tasks. These results suggest that schizophrenics demonstrate a deficit concerning 'response set', especially in the left hemisphere. It is feasible that there may be a correlation with disturbances in integration mechanisms of both hemispheres in schizophrenics.

Recent neuropsychological investigations of schizophrenics have shown that they demonstrate a dysfunction of the left hemisphere (Colburn and Lishman, 1979; Flor-Henry, 1976; Gruzelier and Hammond, 1976; Gur, 1978; Hammond and Gruzelier, 1978). Others have shown that they demonstrate a functional disintegration of both hemispheres (Beaumont and Dimond, 1973; Carr, 1980; Green, 1978). These studies have revealed new aspects concerning the performance deficits of schizophrenics.

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

In order to clarify this role, the present study was conducted to investigate the attentional functioning of each hemisphere in schizophrenics and especially the hemisphere's ability to sustain attention over an extended period. Previous studies have already shown that schizophrenics have disabilities in sustaining attention (Orzack and Kornetsky, 1966; Rappaport *et al*, 1972; Sphon *et al*, 1977; Wohlberg and Kornetsky, 1973). These studies have influenced the authors to carry on this investigation.

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

Method

Subjects

The 14 subjects consisted of randomly selected schizophrenic out-patients (6 males, 8 females) attending the neuropsychiatric clinic at the University of Tokyo Hospital. All patients met the diagnostic criteria for schizophrenic disorders in DSM-III (American Psychiatric Association, 1980). None of them displayed neurological abnormalities, nor evidence of organic brain lesions. Their ages ranged from 23 to 52 years (mean, 35.7; S.D., 7.9), with their period of education ranging from 9 to 16 years (mean, 13.4 years; S.D., 2.3), and all patients had received psychotropic drug therapy. Seventeen normal subjects (11 males, 6 females) comprised the control group. They consisted of drug company employees, hospital staff and university students and had no history of psychiatric or neurological disease. Their ages ranged from 19 to 60 years (mean, 34.6; S.D., 9.7), with their period of education ranging from 12 to 16 years (mean, 15.1 years; S.D., 1.4). All subjects were right-handed, and were free from any hearing disability.

Procedure

In order to examine each cerebral hemisphere's ability to sustain attention, a dichotic detection task was employed; that is, participants were required to listen to dichotically presented non-verbal sounds through headphones and to press a response key upon detection of a particular target sound presented to one ear.

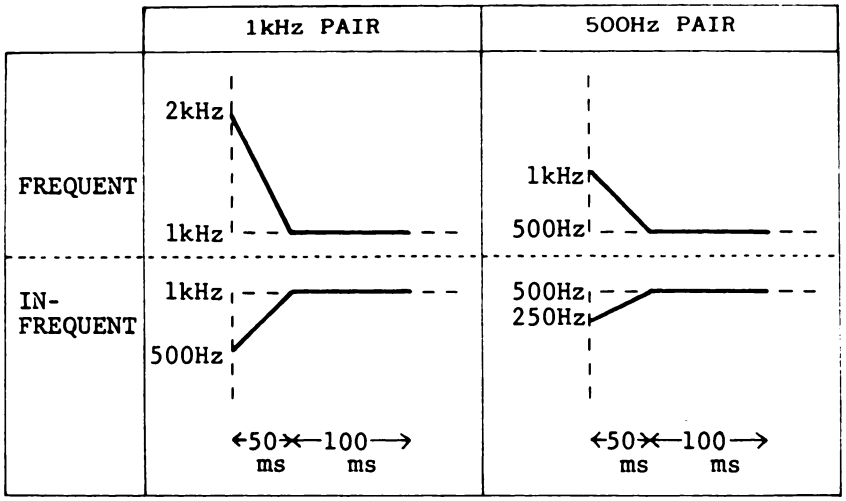

FIG 1.—Schemata of stimuli

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, giving a total duration time of 150 msec. The four stimuli were paired using the basis of equal constant frequency. Each of the paired 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 0.7, than the two sounds in the lower part, with *a priori* probability of 0.3. Infrequent stimulus of one pair, with a constant frequency of 1 kHz (left, lower part of Fig 1), was required to be detected as the 'target stimulus'. Infrequent stimuli were interspersed randomly among all stimuli. Inter-stimulus intervals were of 2 seconds duration, with tone intensities approximating 50 dB SL. 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 (attended ear) being alternated for each session. The attended ear for the first session was also alternated subject by subject. Inter-session intervals were of 5 minutes duration. The participants wore eye masks so as to eliminate visual stimuli. The finger for pressing the response key was limited to the index finger of the hand on the same side as the attended ear.

Results

(1) *Omission and commission errors*

Schizophrenics, as opposed to normal controls, displayed far more marked intra-individual fluctuations in the rates of omission errors as the sessions progressed. The rates of omission errors in schizophrenics tended to increase with the number of sessions, especially when engaged in right-ear tasks. The rates of commission errors, however, remained fairly constant in both schizophrenics and normal controls. The mean rates and standard deviations of omission and commission errors for each session and diagnostic group are shown in Table I. Analysis of variance (ANOVA) revealed that the rates of omission errors, as well as commission errors, in schizophrenics were significantly higher than those of normal controls (omission errors: $F\ (1, 290) = 134.811$, $P < .001$; commission errors: $F\ (1, 290) = 31.673$, $P < .001$). These results also showed that schizophrenics displayed higher rates of commission errors when engaged in right-ear tasks, as opposed to left-ear tasks ($F(1, 290) = 4.403$, $P < .035$).

(2) *Detection Indices*

The detection index (Brown and 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 mean and standard deviation of the detection indices for each session and diagnostic group are shown in Table 1. Analysis of variance (ANOVA) revealed that schizophrenics displayed significantly lower values in the detection index as compared to normal controls ($F(1,290) = 121.291$, $P < .001$). To clarify the intra-individual fluctuation of the detection index over progressive sessions, the ratio of the

https://doi.org/10.1192/bjp.142.5.477 Published online by Cambridge University Press

TABLE I

Omission errors, commission errors, detection index and reaction time for each diagnostic group, ear task, and session

		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

Right-(left-) ear indicates right-(left-) ear task

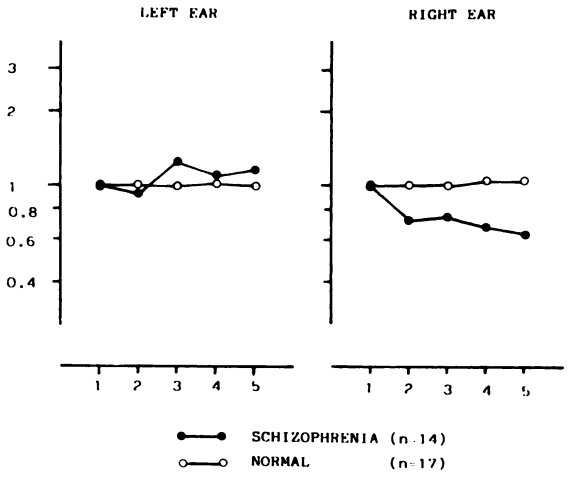

FIG 2.—Mean ratio of detection index for each diagnostic group. Abscissa indicates sessions, and ordinate indicates ratio. Note ordinate is of logarithmic scale.

detection index for each session was calculated implementing '1' as the value of the first session for each ear task. The mean ratio for each session and diagnostic group is plotted in Fig 2. Analysis of variance revealed that in schizophrenics, the ratio of the detection index for right-ear tasks was significantly lower than that of 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 concerning the ratio of the detection index between left and right-ear tasks were found during the 3rd, 4th and 5th sessions. The ratio for the right-ear tasks were lower than those of 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*

The reaction time of the correct responses to the target stimuli remained fairly constant in both schizophrenics and normal controls. The mean reaction time and standard deviation for each session and diagnostic

https://doi.org/10.1192/bjp.142.5.477 Published online by Cambridge University Press

group are shown in Table I. Analysis of variance revealed that schizophrenics' reaction time was significantly slower than that of normal controls ($F(1, 290) = 93.985$, $P < .001$). The mean reaction times for the five sessions for each ear task were 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 already been done on schizophrenics' performance in vigilance tasks (Hammond and Gruzelier, 1978; Mirsky and Kornetsky, 1964; Rappaport *et al,* 1972; Wohlberg and Kornetsky, 1973). These studies are consistent 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 and Gruzelier (1978) have suggested, the schizophrenics' deficit might be 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 as well. The results of this study also suggest that schizophrenics' deficit in the response selection or response organization process, [Broadbent's 'response set' (1971)], becomes greater over an extended period, especially when schizophrenics are engaged in right-ear tasks (left hemisphere tasks). Pribram and McGuiness (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 where the neural transmission is mediated by dopamine. Some disturbances of this system in schizophrenics, may provide a neural basis for the behaviourally observable deficit in the response act, specifically when schizophenics are engaged in left-hemisphere tasks.

The fact that schizophrenics demonstrated more commission errors for right-ear tasks than left-ear tasks may indicate that disturbances of the stimulus analysis process in schizophrenics are also more pronounced in the left hemisphere than in the right.

From 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 that of the stimulus analysis process. This assumption does not rule out the possibility of individual differences in the disturbance patterns.

In this study schizophrenics and normal controls were not matched in sex. Hence, differences in the performance levels between sexes cannot be discussed precisely. However, female subjects, especially female schizophrenics, displayed lower values of DIs for right and left-ear tasks in comparison to male subjects ($F(1,270) = 13.828$, $P < .001$). The authors will carry on further studies to clarify the role that sex difference plays in the performance of such tasks as employed in this study.

The results lend support to the hypothesis of left hemisphere dysfunction in schizophrenics (Colburn and Lishman, 1979; Flor-Henry, 1976; Gruzelier and Hammond, 1976; Gur, 1978; Hammond and 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 the performance level, while the right hemisphere maintains a constant performance level. He also suggested that the integration mechanism of 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 pointed out by other investigators, Beaumont and Dimond, 1973; Carr, 1980; Green, 1978), and that those disturbances may reveal the characteristics of the left hemisphere's inability to sustain an initial performance level.

As is shown in this study, schizophrenics' reaction time for correct responses was slower than that of normal controls, however, they remained fairly constant, even when the number of omission errors increased. This indicates that disturbances of the response set are not directly reflected in the slowness of the reaction time for correct responses in schizophrenics. Regarding the effects of medication on reaction time, Brooks and Weaver (1961) reported that phenothiazines improved schizophrenics' reaction time, while Held *et al* (1970) found no difference in simple reaction time between schizophrenics treated with phenothiazines and those treated with placebos. At present medication with neuroleptics has not seemed to prolong the reaction time in schizophrenics, hence further research is needed to investigate the genesis of slow reaction time in schizophrenics.

Acknowledgements

We would like to thank Miss A. Fukuyasu for her assistance in conducting this experiment. We would also like to thank Miss Karen Rymar for her great effort in correcting the manuscript.

This study was supported in part by a Grant-in-Aid (No. 557268) from the Japanese Ministry of Education, Science and Culture.

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(Received 29 March; revised 1 September 1982)