

## EDITORIAL

### Cerebral laterality and psychopathology: fact and fiction<sup>1</sup>

The plethora of reports on lateralization and psychopathology is part of the *Zeitgeist* that spawned 'neuroscience', and in psychology the concern with brain behaviour relations. The underpinning of abnormal behaviour with a disturbance in lateralization has long been a source of speculation (Zangwill, 1960) and more recently gained impetus from the association of schizophreniform psychoses with left-sided temporal lobe dysfunction and affective psychoses with a corresponding right hemisphere disturbance (Flor-Henry, 1969, 1974). After a decade of intensive research what can be concluded?

For those who acknowledge *terra firma* when morphological deficits are proven, Luchins *et al.* (1979) found with computer tomography that normally occurring lateral asymmetries in the width of frontal and occipital lobes were reversed more often in schizophrenia than in controls. The coincidence between the two asymmetries was not given, but frontal asymmetries were reversed in 13 % of controls and 33 % of patients, with 9 % and 25 % the corresponding percentages for occipital reversals. If reversals of function follow, they may confound comparisons between patients and controls so that in schizophrenia, and to a lesser extent in controls, group distributions of laterality scores will show asymmetries in both directions.

This serves to introduce the complex methodological problems that laterality research faces. One may construe a lateralized disorder in patients not only if the normal asymmetry is absent, or reversed, but also in the presence of the normal asymmetry, provided that performance is reduced below the level of controls. It is essential, therefore, to equate the patient and comparison groups for task difficulty. Nevertheless, quite apart from the results of Luchins *et al.*, it is not entirely satisfactory that all three possible outcomes may be considered evidence of a lateralized deficit to a single hemisphere.

Fortunately, not all approaches are prone to this qualification. If a deficit is defined in terms of the nature of the psychological processing measured, instead of laterality, a conclusion may run that verbal processing compared with spatial processing was deficient, in which case the question 'to which hemisphere do verbal functions belong?' is of secondary importance. With this strategy an experiment should include tasks specific to each hemisphere which in themselves are of equal difficulty. When such requirements are met they also circumvent a major criticism that bedevils psychological studies: namely, the intrusion of factors such as motivation, test anxiety, institutionalism, etc.; such issues will usually affect both hemispheres, and the nature of a lateralized deficit is likely to be neurophysiological. Furthermore, as a global hemispheric deficit is not an issue in current theories, a matter sometimes overlooked, the tests specific to each hemisphere should possess a neuro-anatomical equivalence. This requirement is more easily met when measuring the earlier stages of processing or in tasks processed by either hemisphere. The transmission of information between the hemispheres may also be examined by comparing material transmitted directly to the specialized hemisphere with that directed via the non-specialized one.

Returning to the review of evidence, an association between abnormal lateralization and schizophrenia has been found in the handedness of twins, one or both of whom have psychosis (Boklage, 1977; Luchins *et al.* 1980). Concordance for schizophrenia was 93 % when both twins were dextral, but merely 23 % when one was sinistral. Left-handed cases also showed milder forms of the disorder. Surveys of handedness in psychotic populations are contradictory, with evidence of more sinistrality (Dvirskii, 1976; Gur, 1977; Lishman & McMeekan, 1976; Flor-Henry, 1979*a*), and dextrality (Taylor *et al.* 1980), or no difference from controls (Oddy & Lobstein, 1972; Wahl, 1976). Neverthe-

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less, given that when distributions of handedness in psychotic patients differ from control distributions the differences are marginal, data from this source are of peripheral interest in elucidating the mechanisms of dysfunction. Left and mixed handedness have also been associated with non-psychotic psychopathology (Bakan, 1973; Fitzhugh, 1973; Orme, 1970; Zangwill, 1960).

Attempts to lateralize dysfunction with neuropsychological tests have had limited success. While some have found evidence of a disturbance to the speech dominant hemisphere in schizophrenia, or the opposite hemisphere in mania and depression (Klonoff *et al.* 1970; Gruzelier & Hammond, 1976; Flor-Henry & Yeudall, 1979; Abrams & Taylor, 1979), this is a far from universal finding (Malek, 1978). Undoubtedly problems of sampling, inappropriate comparison groups, difficulty in controlling drugs, Parkinsonian side-effects and fatiguability of patients when faced with large batteries of tests contribute to the confusion. Also, such tests were designed to measure brain damage and there is little evidence that brain damage in a gross form, even when detected (e.g. Johnstone *et al.* 1978), is necessary for the primary schizophrenic disturbance.

In their attempts to measure more discrete processes experimental psychologists have devoted most attention to the schizophrenic psychoses. In the case of visual processing there are eight studies using a tachistoscope, a device which enables stimuli to be transmitted to one hemisphere before the other. In the first (Beaumont & Dimond, 1973) a deficiency was revealed in the integration of information between the hemispheres as well as a left hemisphere deficit. Others have revealed a deficiency when information is projected directly to the left hemisphere, rather than indirectly via the transcallosal pathway. Gur (1978) found for both paranoid and non-paranoid patients that accuracy in recalling letters was poorer when projected over the direct pathway. This contrasted with adequate performance on a right hemisphere task irrespective of input channel. Connolly *et al.* (1979) found similar results insofar as schizophrenic and hypomanic patients took *longer* to process verbal material when presented directly to the left hemisphere – accuracy was not affected. While the same phenomenon was not reproduced by Eaton (1979), who examined patients both on and off drugs, her mean results suggest that the effect may have existed on drugs but not before. As the patients of Gur and Connolly *et al.* were medicated, the possibility of a drug explanation should be investigated. Eaton found a left hemisphere advantage in processing verbal material in both schizophrenic patients and controls; but the performance of schizophrenic patients was poorer, indicating a verbal deficit, particularly as both groups showed a similar ability on tasks involving the right hemisphere. Hillsberg (1979) also found in schizophrenics poorer left than right hemisphere processing in deciding whether pairs of arrows pointed in the same or opposite directions. There was no interhemispheric transfer deficit. In a study of symptomatic schizophrenic out-patients, maintained on drugs, male patients failed to show the normal advantage in processing verbal material in the left hemisphere (Colbourn & Lishman, 1979).

Unlike the above studies which found no evidence of right hemisphere deficits in detecting spatial information, Pic'l *et al.* (1979) report a verbal deficit in schizophrenia coupled with a spatial deficit in non-paranoid patients. The latter was attributed to a problem in integrating information between the hemispheres because normals and paranoid patients counted dots in a serial fashion, thereby requiring analytic processes of the left hemisphere integrated with spatial abilities of the right hemisphere. Non-paranoids utilized the right hemisphere only. An alternative explanation might be that non-paranoid patients were restricted to right hemisphere processing because the analytic ability of their left hemisphere was deficient. The authors explained away the verbal deficit found in both types of schizophrenia because it correlated with years spent at school. However, in the case of paranoids, this explanation is unconvincing – their education was no different from that of controls. Furthermore, paranoids showed a deficit on a similarities test, which is indicative of a left hemisphere deficit (McFie, 1975) and one previously found in chronic schizophrenia (Gruzelier & Hammond, 1976). Turning to the non-paranoid group, even if a deficit does correlate with years of schooling this does not exclude the possibility that the left hemisphere disability predisposes a vulnerability to schizophrenia and limits educational progress. A similar deficiency in children with a schizophrenic parent (Gruzelier *et al.* 1979) supports this supposition. Thus a left-sided deficit could account for their results.

This is not to exclude the possibility of a dysfunctional right hemisphere in schizophrenia. Gur (1979) required paranoid and non-paranoid patients with unrestricted vision to detect the difference between pairs of pictures placed side by side or seen successively. While all groups were less accurate with successive presentation, and schizophrenic patients were poorer overall, patients of both categories were *slower* when pictures were presented side by side. This was likened to the results of an unpublished study of neurological patients with right hemisphere brain damage which, on the face of it, would appear to support a right hemisphere deficit in schizophrenia. Instead, this was interpreted as evidence of an over-reliance on a dysfunctional left hemisphere. Perhaps in the service of parsimony a right hemisphere explanation should be preferred or be an alternative.

Returning to the divided field tachistoscope studies, Clooney & Murray (1977) required patients to identify an array of letters as the same or different. While no lateral asymmetries in processing were found in schizophrenic patients or controls, patients were slower overall than controls, and paranoid patients were progressively slower as the size of the array increased. This anomaly in paranoids was interpreted as arising from their dependence on serial (left hemisphere) rather than parallel (right hemisphere) processing.

When we turn to studies of auditory function, the plot thickens further, though the auditory symptoms that accompany psychosis, auditory functions of the temporal lobe, and psychotic-like states that accompany temporal lobe dysfunction (Davison & Bagley, 1969) led us to suppose a more coherent outcome. The functional neuroanatomy of the auditory system is such that each ear projects to both hemispheres but the contralateral pathways are dominant. Ipsilateral input may be suppressed by requiring the immediate recall of competing input presented to both ears simultaneously. This was verified in patients with sections of the transcallosal pathway (Sparks & Geschwind, 1968). Recall of verbal material from the right ear was normal, whereas from the left ear it was substantially reduced. Presumably right ear input was processed by the contralateral pathway and left ear input depended on the transcallosal pathway from the right to left hemisphere. Using a closely similar procedure, three studies (Lerner *et al.* 1977; Lishman *et al.* 1978; Gruzelier & Hammond, 1979, 1980) have shown a *larger* lateral asymmetry in favour of the right ear in many schizophrenic patients compared with controls. Two of the studies found that this characterized paranoid schizophrenia (Gruzelier & Hammond, 1979, 1980; Lerner *et al.* 1977, as reanalysed by Nachshon, 1980). This might imply a deficit in transferring information between the hemispheres but, by controlling attentional bias to either side, the asymmetry could be explained as an over-reliance on direct right ear input to the left hemisphere rather than as a defective transcallosal pathway (Gruzelier & Hammond, 1979); levels of performance did not differ between patients and controls. The dependence on left hemisphere processing in paranoid schizophrenia is consistent with evidence in the visual modality (Clooney & Murray, 1977; Pic'1 *et al.* 1979).

Green and colleagues (Green *et al.* 1979; Green & Kotenko, 1980) report a larger than normal right ear preference in the speech comprehension of schizophrenic patients. The level of performance with which the lateral difference was correlated was below that of controls. These results are open to a number of interpretations: for example, a left hemisphere verbal deficit coupled with an attentional bias to the right ear, or an attentional bias coupled with a lack of motivation which lowered performance. However, poorer comprehension when speech was heard binaurally rather than monaurally suggests a problem in integrating information between the hemispheres, as does evidence of longer reaction times to binaural than to monaural stimuli in schizophrenic patients (Gruzelier & Hammond, 1979). The locus of dysfunction might be lateralized or reside in interhemispheric pathways. Dichotic listening studies have shown a left hemisphere inhibitory deficit through the inability of schizophrenic patients to withhold recall of words in the right ear in favour of the left ear when right ear words were twenty decibels louder than left ear words (Bull, 1972; Gruzelier & Hammond, 1980). Performance of a corresponding condition which required suppression of left ear words was no worse than controls. By examining serial position effects the latter authors conclude that there were a number of left hemisphere deficits of higher order processing, which involved semantic encoding, retrieval and response organization. These could include the reception of information transmitted from the right hemisphere.

Other studies, while showing the normal right ear advantage in processing language-related tasks, found a poorer level of performance in schizophrenic patients than controls, consistent with a left hemisphere deficit in patients (Bruder & Yozowitz, 1979; Caudrey & Kirk, 1979). In fact, Caudrey & Kirk showed in schizophrenia impairments in a left hemisphere task coexisting with normal performance on a right hemisphere task, whereas in depression there was the reverse asymmetry. In two other studies the expected right ear preference was absent in schizophrenia. This was shown by Colbourn & Lishman (1979) in a subgroup of male patients, and by Wexler & Heninger (1979) who examined patients repeatedly before and during treatment and found the normal asymmetry reinstated with improvement of symptoms on drugs. The magnitude of the asymmetries was within normal limits.

A systematic reversal of asymmetries in auditory processing with the withdrawal and later reinstatement of drug was reported by Hammond & Gruzelier (1978). The effect was related to dose level. Phenothiazines appeared to increase the arousability of the left hemisphere relative to the right, an effect which may facilitate or impair performance depending on existing arousal levels and intensity of input (Gruzelier, 1979*a*). Alterations of lateralized differences on drug have also been found in the electroencephalogram (Goldstein *et al.* 1965; Serafetinides, 1972, 1973), palmar electrodermal activity (Gruzelier & Yorkston, 1978), visual processing (Eaton, 1979) and reaction times (Gruzelier & Hammond, 1979).

Studies of the tactile modality have provided the main evidence of Dimond and his colleagues for a disorder of interhemispheric communication in schizophrenia (Green, 1978; Dimond, 1979; Dimond *et al.* 1979; Carr, 1980). Other workers (Kugler & Henley, 1979; Weller & Kugler, 1979), as reviewed elsewhere (Gruzelier, 1979*a*), have not found conclusive support for the theory, though they have obtained evidence of left hemisphere dysfunction. In a more recent report of 24 middle-aged, institutionalized schizophrenic patients a third were found to exhibit errors in naming objects with eyes closed, particularly when placed in the left hand, a condition which required callosal transmission to the language processors of the left hemisphere (Dimond *et al.* 1979). However, on one of the four test occasions no errors were made in either hand. The study would appear to substantiate the impression that the callosal deficit when manifested in schizophrenia is an elusive one and often coexists with left hemisphere dysfunction. The problem may be spasmodic and has been attributed to one of impaired transmission (Beaumont & Dimond, 1973), a noisy channel (Butler, 1979; Dimond *et al.* 1979), a loss of contralateral inhibition (Gruzelier, 1978; Wexler & Heninger, 1979) and a dominance of transcallosal influences (Tress *et al.* 1979).

A variety of psychophysiological indices have provided evidence of an abnormal balance of activity between the hemispheres in psychosis. Under controlled conditions the majority of studies show that schizophrenic patients direct their eyes rightwards more often than patients with affective disorders or controls (Gur, 1978; Schweitzer *et al.* 1978; Myslobodsky *et al.* 1979; Schweitzer, 1979). This was attributed to an over-activation of the left hemisphere. However, Sandel & Alcorn (1980) found more leftward movements in non-paranoid schizophrenia, as well as in depression and alcoholism, with movements in both directions in manic-depression, schizo-affective disorders and psychopathy. No normal controls were tested. Measures of activation with electro-encephalographic techniques obtained in the resting state or during cognitive activity have produced complex results implicating both hemispheres in psychosis and providing evidence of activation inappropriate to the nature of the task (Flor-Henry *et al.* 1979; Perris & Monakhov, 1979; Goldstein, 1979; Shaw *et al.* 1979; Weller & Montague, 1979; and see Gruzelier, 1979*a* for a review). These studies, together with those which average discrete changes to trains of identical stimuli (Buchsbaum *et al.* 1979; Shagass *et al.* 1979; Tress *et al.* 1979), suggest that topographic analysis may prove rewarding in differentiating between psychiatric groups (e.g. Shagass *et al.* 1980). Greater clarity may also arise in correlating symptoms rather than diagnostic categories with EEG topography and coherence between recording sites within and between the hemispheres (Perris & Monakhov, 1979). The recording of phasic changes in experimental tasks will assist in localizing and defining processing deficits.

An abnormal balance in hemispheric influences has also been shown in the electrical conductivity of the skin recorded from palmar surfaces. Schizophrenic patients, particularly chronic ones, tend to

have larger orienting and non-specific responses on the right hand, with the opposite asymmetry shown in some depressives (Fisher & Cleveland, 1959; Gruzelier, 1973, 1979*b*; Gruzelier & Hammond, 1977; Gruzelier & Venables, 1974; Myslobodsky & Horesh, 1978; Uherik, 1975). On the whole normal subjects have symmetrical responses or small deviations in either direction. The limbic influence on these asymmetries is reinforced by recent evidence suggesting that it is predominantly an emotional component that determines the direction of the electrodermal asymmetry. By relating them to syndromes from the Present State Examination (Wing *et al.* 1974) and ratings on the Brief Psychiatric Rating Scale (Overall & Gorham, 1962) it was found that hypomania, depressive delusions and pressure of speech were among the characteristics of admissions for schizophrenia with larger left-sided responses, whereas blunted affect, emotional withdrawal, slowness, catatonia, motor retardation and conceptual disorganization characterized the schizophrenic patients with larger right-sided responses (Gruzelier *et al.* 1981).

Regarding the affective disorders and lateralization, essentially there have been two rival notions. One is that mania and depression are a result of right hemisphere dysfunction, and are thereby distinguished from schizophrenia. The second is that emotional polarity differs between the hemispheres, with positive emotions and mania on the left side and negative emotions and depression on the right side. Certainly there is a growing body of experimental data with normal subjects indicating that mood is controlled by the right hemisphere (see Gainotti, 1979). Furthermore, in patients, schizophrenia and affective disorders have been distinguished by lateral differences in facets of auditory processing, neuropsychological tests, and measures of muscle activity, electrodermal responses, conjugate eye movements and EEG, most of which implicate the right hemisphere in affective disorders (Abrams & Taylor, 1979; Caudrey & Kirk, 1979; Flor-Henry & Yeudall, 1979; Flor-Henry *et al.* 1979; Gruzelier & Venables, 1974; Myslobodsky & Horesh, 1978; Bruder & Yozowitz, 1979). Equally there is support for an association of euphoria and depression, and corresponding psychopathology, with the left and right hemispheres respectively (see Gainotti, 1979). This has led Flor-Henry (1979*a, b*) to conceive a complex model of how mood is organized by both hemispheres, with transcallosal influences posited to explain hemispheric differences in the polarity of mood and with distinctions made between the syndromes of mania and depression, on the one hand, and normal reactions of euphoria and depression, on the other. While some of the evidence is compelling, it is also true that there is evidence of the opposite relation: namely, euphoric reactions deriving from the right hemisphere and depressive reactions from the left hemisphere. Evidence with normals indicates reciprocal influences between the hemispheres in the control of arousal and habituation (Gruzelier *et al.* 1980) and offers a means whereby each hemisphere has the potential to evoke euphoria or depression, depending on the state of imbalance between excitatory and inhibitory subsystems with contralateral projections. Divergent findings on the lateralization of the emotions may be reconciled through elucidating mechanisms of this type.

Psychopathy and various neurotic disorders have also been associated with a disturbance of lateralization (Zangwill, 1960). Yeudall & Fromm-Auch (1979) amassed evidence largely from neuropsychological tests of a dominant hemisphere deficit in various groups of children and adults with behaviour disturbances. Hare (1979) was unable to support this in a tachistoscope study with psychopaths. The lateralization of some neurotic disorders, such as conversion hysteria and psychogenic pain to the left side of the body, has been explained as a mode of expression for the non-verbal, right hemisphere (Galín, 1974; Fleminger *et al.* 1980). However, not all reports indicate a preponderance of left-sided symptoms.

The simple notions that have generated much of the research reviewed above have now given way to more complex models (e.g. Flor-Henry, 1979*a, b*). Schizophrenia is unlikely to be a disorder of strictly one hemisphere or a disconnection syndrome in the conventional sense (cf. Geschwind, 1965). This review of evidence suggests a new working model as follows. In schizophrenia the moment to moment allocation of capacity between the hemispheres is often at odds with hemispheric specialization. In paranoid schizophrenia and schizo-affective cases with hypomania there is an over-reliance on the left or speech dominant hemisphere. In non-paranoid schizophrenia and schizo-affective cases with depression reliance is on the right hemisphere. Such a distinction between paranoid and

non-paranoid schizophrenia, invoked because of the differences revealed in many reports above, may need qualifying and be replaced by partially overlapping syndromes, perhaps incorporating an arousal/motility dimension (cf. Gruzelier & Hammond, 1979, 1980). Primary delusions, as well as flat incongruous affect and catatonic features, all correlated with left hemisphere lesions in the survey by Davison & Bagley (1969) of schizophrenic-like psychoses associated with organic disorders. Therefore it is likely that the primary disturbance in schizophrenia is in the left hemisphere and affects the right hemisphere through transcallosal influences. It would be parsimonious, though too good to be true, if the affective disorders involved corresponding right hemisphere dysfunction with mania showing a dependence on the left hemisphere and depression a dependence on the right hemisphere.

It has been suggested (Weller & Montague, 1979; Venables, 1980) that in schizophrenia the disturbance develops in the right hemisphere and spreads to the left with chronicity. There is scant evidence in support of this and it should be noted that the evidence called upon of Itil *et al.* (1974), whereby there was an accentuation of EEG abnormalities in the right hemisphere in children with a schizophrenic parent, coexisted with evidence of verbal deficits and in some children superior spatial-perceptual ability (Gruzelier *et al.* 1979).

From this review it is clear that, while the neuropsychology of psychopathological states is in its infancy, it is a new and promising line of enquiry which provides some integration of hitherto numerous and unrelated reports of patient-control differences. Apart from its scientific interest, it may have clinical applications. Evidence of objective, biological differences between patients will assist with diagnosis. The likelihood of hemispheric asymmetries in neurotransmitter systems (Glick *et al.* 1977; Oke *et al.* 1978), and the evidence of alterations in lateralized processes on neuroleptics, may elucidate the therapeutic actions of drugs in psychiatric practice. Whatever the outcome, the fact of the matter is that the study of the abnormal brain has already led to insights about the workings of the normal brain.

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## REFERENCES

- Abrams, R. & Taylor, M. A. (1979). Laboratory studies in the validation of psychiatric diagnoses. In *Hemisphere Asymmetries of Function in Psychopathology* (ed. J. H. Gruzelier and P. Flor-Henry), pp. 363-372. Elsevier/North Holland Biomedical Press: Amsterdam.
- Bakan, P. (1973). Left-handedness and alcoholism. *Perceptual and Motor Skills* 36, 514.
- Beaumont, J. G. & Dimond, S. J. (1973). Brain disconnection and schizophrenia. *British Journal of Psychiatry* 123, 661-662.
- Boklage, C. E. (1977). Schizophrenia, brain asymmetry development and twinning: cellular relationship with etiological and possibly prognostic implication. *Biological Psychiatry* 12, 17-35.
- Bruder, G. E. & Yozawitz, A. (1979). Central auditory processing and lateralization in psychiatric patients. In *Hemisphere Asymmetries of Function in Psychopathology* (ed. J. H. Gruzelier and P. Flor-Henry), pp. 561-580. Elsevier/North Holland Biomedical Press: Amsterdam.
- Buchsbaum, M. S., Carpenter, W. T., Fedio, P., Goodwin, F. K., Murphy, D. L. & Post, R. M. (1979). Hemispheric differences in evoked potential enhancement by selective attention to hemiretinally presented stimuli in schizophrenic, affective and post-temporal lobectomy patients. In *Hemisphere Asymmetries of Function in Psychopathology* (ed. J. H. Gruzelier and P. Flor-Henry), pp. 317-328. Elsevier/North Holland Biomedical Press: Amsterdam.
- Bull, H. C. (1972). Speech perception and short-term memory in schizophrenia. Unpublished doctoral dissertation: University of London.
- Butler, S. (1979). Interhemispheric relations in schizophrenia. In *Hemisphere Asymmetries of Function in Psychopathology* (ed. J. H. Gruzelier and P. Flor-Henry), pp. 47-63. Elsevier/North Holland Biomedical Press: Amsterdam.
- Carr, S. A. (1980). Interhemispheric transfer of stereognostic information in chronic schizophrenics. *British Journal of Psychiatry* 136, 53-58.
- Caudrey, D. J. & Kirk, K. (1979). The perception of speech in schizophrenia and affective disorders. In *Hemisphere Asymmetries of Function in Psychopathology* (ed. J. H. Gruzelier and P. Flor-Henry), pp. 581-601. Elsevier/North Holland Biomedical Press: Amsterdam.
- Clooney, J. L. & Murray, D. J. (1977). Same-different judgments in paranoid and non-paranoid patients: a laterality study. *Journal of Abnormal Psychology* 86, 655-658.
- Colbourn, C. J. & Lishman, W. A. (1979). Lateralisation of function and psychotic illness: a left hemisphere deficit? In *Hemisphere Asymmetries of Function in Psychopathology* (ed. J. H. Gruzelier and P. Flor-Henry), pp. 539-560. Elsevier/North Holland Biomedical Press: Amsterdam.
- Connolly, J. F., Gruzelier, J. H., Kleinman, K. M. & Hirsch, S. R. (1979). Lateralised abnormalities in schizophrenic, depressive and non-psychotic patients in hemispheric specific tachistoscopic tasks. In *Hemisphere Asymmetries of Function in Psychopathology* (ed. J. H. Gruzelier and P. Flor-Henry), pp. 647-672. Elsevier/North Holland Biomedical Press: Amsterdam.
- Davison, K. & Bagley, C. R. (1969). Schizophrenia-like psychoses associated with organic disorders of the central nervous system: a review of the literature. In *Current Problems in Neuropsychiatry* (ed. R. N. Herrington), pp. 113-184. Royal Medico-Psychological Association, Headley Bros.: Ashford, Kent.
- Dimond, S. J. (1979). Disconnection and psychopathology. In *Hemisphere Asymmetries of Function in Psychopathology* (ed. J. H. Gruzelier and P. Flor-Henry), pp. 35-46. Elsevier/North Holland Biomedical Press: Amsterdam.

- Dimond, S. J., Scammell, R. E., Pryce, J. Q., Huss, D. & Gray, C. (1979). Callosal transfer and left-hand anomia in schizophrenia. *Biological Psychiatry* **14**, 735–739.
- Dvirskii, A. E. (1976). Functional asymmetry of the cerebral hemispheres in clinical types of schizophrenia. *Neuroscience and Behavioral Physiology (Washington)* **7**, 236–239.
- Eaton, E. M. (1979). Hemisphere-related visual information processing in acute schizophrenia before and after neuroleptic treatment. In *Hemisphere Asymmetries of Function in Psychopathology* (ed. J. H. Gruzelier and P. Flor-Henry), pp. 511–526. Elsevier/North Holland Biomedical Press: Amsterdam.
- Fisher, S. & Cleveland, S. E. (1959). Right–left body reactivity problems in disorganised states. *Journal of Nervous and Mental Disease* **128**, 396–400.
- Fitzhugh, K. B. (1973). Some neuropsychological features of delinquent subjects. *Perceptual and Motor Skills* **36**, 494.
- Fleminger, J. J., McClure, G. M. & Dalton, R. (1980). Lateral response to suggestion in relation to handedness and the side of psychogenic symptoms. *British Journal of Psychiatry* **136**, 562–566.
- Flor-Henry, P. (1969). Psychoses and temporal lobe epilepsy: a controlled investigation. *Epilepsia* **10**, 363–395.
- Flor-Henry, P. (1974). Psychosis, neurosis and epilepsy. *British Journal of Psychiatry* **124**, 144–150.
- Flor-Henry, P. (1979a). Laterality, shifts of cerebral dominance, sinistrality and psychosis. In *Hemisphere Asymmetries of Function in Psychopathology* (ed. J. H. Gruzelier and P. Flor-Henry), pp. 3–20. Elsevier/North Holland Biomedical Press: Amsterdam.
- Flor-Henry, P. (1979b). On certain aspects of the localisation of the cerebral systems regulating and determining emotions. *Biological Psychiatry* **14**, 677–697.
- Flor-Henry, P. & Yeudall, L. T. (1979). Neuropsychological investigation of schizophrenia and manic-depressive psychoses. In *Hemisphere Asymmetries of Function in Psychopathology* (ed. J. H. Gruzelier and P. Flor-Henry), pp. 341–362. Elsevier/North Holland Biomedical Press: Amsterdam.
- Flor-Henry, P., Koles, Z. J., Howarth, B. G. & Burton, L. (1979). Neurophysiological studies of schizophrenia, mania and depression. In *Hemisphere Asymmetries of Function in Psychopathology* (ed. J. H. Gruzelier and P. Flor-Henry), pp. 189–222. Elsevier/North Holland Biomedical Press: Amsterdam.
- Gainotti, G. (1979). The relationships between emotions and cerebral dominance: a review of clinical and experimental evidence. In *Hemisphere Asymmetries of Function in Psychopathology* (ed. J. H. Gruzelier and P. Flor-Henry), pp. 21–34. Elsevier/North Holland Biomedical Press: Amsterdam.
- Galín, D. (1974). Implications for psychiatry of left and right cerebral specialisations. A neuropsychological context for unconscious processes. *Archives of General Psychiatry* **31**, 572–583.
- Geschwind, N. (1965). Disconnection syndromes in animals and man. *Brain* **88**, 237–294.
- Glick, S. D., Jerussi, T. P. & Zimmersberg, B. (1977). Behavioural and neuropharmacological correlates of nigrostriatal asymmetry in rats. In *Lateralisation in the Nervous System* (ed. S. Harnad, R. W. Doty, L. Goldstein, J. Jaynes and S. Krauthamer), pp. 213–250. Academic Press: London.
- Goldstein, L. (1979). Some relationships between quantified hemispheric EEG and behavioural states in man. In *Hemisphere Asymmetries of Function in Psychopathology* (ed. J. H. Gruzelier and P. Flor-Henry), pp. 237–254. Elsevier/North Holland Biomedical Press: Amsterdam.
- Goldstein, L., Sugarman, A. A., Stolberg, H., Murphee, H. B. & Pfeiffer, C. C. (1965). Electro-cerebral activity in schizophrenics and non-psychotic subjects: quantitative EEG amplitude analyses. *Electroencephalography and Clinical Neurophysiology* **19**, 350–361.
- Green, P. (1978). Defective interhemispheric transfer in schizophrenia. *Journal of Abnormal Psychology* **87**, 472–480.
- Green, P. & Kotenko, V. (1980). Superior speech comprehension in schizophrenics under monaural versus binaural listening conditions. *Journal of Abnormal Psychology* **89**, 399–408.
- Green, P., Glass, A. & O'Callaghan, M. A. J. (1979). Some implications of abnormal hemisphere interaction in schizophrenia. In *Hemisphere Asymmetries of Function in Psychopathology* (ed. J. H. Gruzelier and P. Flor-Henry), pp. 431–448. Elsevier/North Holland Biomedical Press: Amsterdam.
- Gruzelier, J. H. (1973). Bilateral asymmetry of skin conductance orienting activity and levels in schizophrenia. *Journal of Biological Psychology* **1**, 21–41.
- Gruzelier, J. H. (1978). Bimodal states of arousal and lateralised dysfunction in schizophrenia: the effect of chlorpromazine. In *The Nature of Schizophrenia: New Approaches to Research and Treatment* (ed. L. Wynne, R. Cromwell and S. Matthysse), pp. 167–187. Wiley: New York.
- Gruzelier, J. H. (1979a). Synthesis and critical review of the evidence for hemisphere asymmetries of function in psychopathology. In *Hemisphere Asymmetries of Function in Psychopathology* (ed. J. H. Gruzelier and P. Flor-Henry), pp. 647–672. Elsevier/North Holland Biomedical Press: Amsterdam.
- Gruzelier, J. H. (1979b). Lateral asymmetries in electrodermal activity and psychosis. In *Hemisphere Asymmetries of Function in Psychopathology* (ed. J. H. Gruzelier and P. Flor-Henry), pp. 149–168. Elsevier/North Holland Biomedical Press: Amsterdam.
- Gruzelier, J. H. & Hammond, N. V. (1976). Schizophrenia: a dominant hemisphere temporal-limbic disorder? *Research Communications in Psychology, Psychiatry and Behaviour* **1**, 33–72.
- Gruzelier, J. H. & Hammond, N. V. (1977). The effect of chlorpromazine upon bilateral asymmetries of bioelectric skin reactivity in schizophrenia. *Studia Psychologica* **19**, 40–50.
- Gruzelier, J. H. & Hammond, N. V. (1979). Lateralised auditory processing in medicated and unmedicated schizophrenic patients. In *Hemisphere Asymmetries of Function in Psychopathology* (ed. J. H. Gruzelier and P. Flor-Henry), pp. 603–638. Elsevier/North Holland Biomedical Press: Amsterdam.
- Gruzelier, J. H. & Hammond, N. V. (1980). Lateralised deficits and drug influences on the dichotic listening of schizophrenic patients. *Biological Psychiatry* **15**, 759–779.
- Gruzelier, J. H. & Venables, P. H. (1974). Two-flash threshold sensitivity and  $\beta$  in normal subjects and schizophrenics. *Quarterly Journal of Experimental Psychology* **26**, 594–604.
- Gruzelier, J. H. & Yorkston, N. J. (1978). Propranolol and schizophrenia: objective evidence of efficacy. In *Biological Basis of Schizophrenia* (ed. W. and G. Hemmings), pp. 127–146. MTP Press: Lancaster.
- Gruzelier, J. H., Mednick, S. A. & Schulsinger, F. (1979). Lateralised impairments in the WISC profiles of children at genetic risk for psychopathology. In *Hemisphere Asymmetries of Function in Psychopathology* (ed. J. H. Gruzelier and P. Flor-Henry), pp. 105–110. Elsevier/North Holland Biomedical Press: Amsterdam.
- Gruzelier, J. H., Eves, F. F. & Connolly, J. F. (1980). Reciprocal hemispheric influences on response habituation in the electrodermal system. Paper presented to conference on Lateral Asymmetries and Cerebral Function, Leicester, September 1980. (Submitted for publication.)
- Gruzelier, J. H., Connolly, J. C. & Hirsch, S. R. (1981). Altered brain functional organisation in psychosis: brain

- behaviour relationships. In *Clinical Neurophysiological Aspects of Psychopathological Conditions*. Karger: Basle (in the press).
- Gur, R. E. (1977). Motoric laterality imbalance in schizophrenia: a possible concomitant of left hemisphere dysfunction. *Archives of General Psychiatry* 34, 33–37.
- Gur, R. E. (1978). Left hemisphere dysfunction and left hemisphere overactivation in schizophrenia. *Journal of Abnormal Psychology* 87, 226–238.
- Gur, R. E. (1979). Cognitive concomitants of hemispheric dysfunction in schizophrenia. *Archives of General Psychiatry* 36, 269–274.
- Hammond, N. V. & Gruzeliel, J. H. (1978). Laterality, attention and rate effects in the auditory temporal discrimination of chronic schizophrenics: the effect of chlorpromazine. *Quarterly Journal of Experimental Psychology* 30, 91–103.
- Hare, R. D. (1979). Psychopathy and laterality of cerebral function. *Journal of Abnormal Psychology* 28, 605–610.
- Hillsberg, B. (1979). A comparison of visual discrimination performance of the dominant and nondominant hemispheres in schizophrenia. In *Hemisphere Asymmetries of Function in Psychopathology* (ed. J. H. Gruzeliel and P. Flor-Henry), pp. 527–538. Elsevier/North Holland Biomedical Press: Amsterdam.
- Itil, T. M., Hsu, W., Saletu, B. & Mednick, S. A. (1974). Computer EEG and auditory evoked potential investigations in children at high risk for schizophrenia. *American Journal of Psychiatry* 131, 892–900.
- Johnstone, E. C., Crow, T. J., Frith, C. D., Stevens, M., Kreef, L. & Husband, J. (1978). The dementia of dementia praecox. *Acta psychiatrica Scandinavica* 57, 305–324.
- Klonoff, H., Fibiger, C. G. & Hutton, G. H. (1970). Neuro-psychological problems in chronic schizophrenia. *Journal of Nervous and Mental Disease* 150, 291–300.
- Kugler, B. T. & Henley, S. H. A. (1979). Laterality effects in the tactile modality in schizophrenia. In *Hemisphere Asymmetries of Function in Psychopathology* (ed. J. H. Gruzeliel and P. Flor-Henry), pp. 475–489. Elsevier/North Holland Biomedical Press: Amsterdam.
- Lerner, J., Nachshon, I. & Carmon, A. (1977). Responses of paranoid and non-paranoid schizophrenics in a dichotic listening task. *Journal of Nervous and Mental Disease* 164, 247–252.
- Lishman, W. A. & McMeekan, E. R. L. (1976). Hand preference in psychiatric patients. *British Journal of Psychiatry* 129, 158–166.
- Lishman, W. A., Toone, B. K., Colbourn, C. J., McMeekan, E. R. L. & Mance, R. M. (1978). Dichotic listening in psychotic patients. *British Journal of Psychiatry* 132, 333–341.
- Luchins, D. J., Weinberger, D. R. & Wyatt, R. J. (1979). Schizophrenia: evidence of a subgroup with reversed cerebral asymmetry. *Archives of General Psychiatry* 36, 1309–1311.
- Luchins, D., Pollin, W. & Wyatt, R. J. (1980). Laterality in monozygotic schizophrenic twins: an alternative hypothesis. *Biological Psychiatry* 15, 87–94.
- Malek, J. (1978). Neuropsychological assessment of schizophrenia versus brain damage: a review. *Journal of Nervous and Mental Disease* 166, 507–516.
- McFie, J. (1975). *The Assessment of Organic Impairment*. Academic Press: London.
- Myslobodsky, M. S. & Horesh, N. (1978). Bilateral electrodermal activity in depressive patients. *Biological Psychiatry* 6, 111–120.
- Myslobodsky, M., Mintz, M. & Tomer, R. (1979). Asymmetric reactivity of the brain and components of hemispheric imbalance. In *Hemisphere Asymmetries of Function in Psychopathology* (ed. J. H. Gruzeliel and P. Flor-Henry), pp. 125–148. Elsevier/North Holland Biomedical Press: Amsterdam.
- Nachshon, G. (1980). Hemispheric dysfunctions in schizophrenia. *Journal of Nervous and Mental Disease* 168, 241–242.
- Oddy, H. C. & Lobstein, T. J. (1972). Hand and eye dominance in schizophrenia. *British Journal of Psychiatry* 120, 331–332.
- Oke, A., Keller, R., Mefford, I. & Adams, R. (1978). Lateralisation of norepinephrine in human thalamus. *Science* 200, 1411–1433.
- Orme, J. E. (1970). Left-handedness, ability and emotional instability. *British Journal of Social and Clinical Psychology* 9, 87–88.
- Overall, J. E. & Gorham, D. R. (1962). The Brief Psychiatric Rating Scale. *Psychological Reports* 10, 799–812.
- Perris, C. & Monakhov, K. (1979). Depressive symptomatology and systemic structural analysis of the EEG. In *Hemisphere Asymmetries of Function in Psychopathology* (ed. J. H. Gruzeliel and P. Flor-Henry), pp. 223–236. Elsevier/North Holland Biomedical Press: Amsterdam.
- Pic'1, A. K., Magaro, P. A. & Wade, E. A. (1979). Hemispheric functioning in paranoid and nonparanoid schizophrenia. *Biological Psychiatry* 14, 891–903.
- Sandel, A. & Alcorn, J. D. (1980). Individual hemisphericity and maladaptive behaviors. *Journal of Abnormal Psychology* 89, 514–517.
- Schweitzer, L. (1979). Differences of cerebral lateralisation among schizophrenic and depressed patients. *Biological Psychiatry* 14, 721–733.
- Schweitzer, L., Becker, E. & Walsh, H. (1978). Abnormalities of cerebral lateralisation in schizophrenic patients. *Archives of General Psychiatry* 35, 982–985.
- Serafetinides, E. A. (1972). Laterality and voltage in the EEG of psychiatric patients. *Diseases of the Nervous System* 33, 422.
- Serafetinides, E. A. (1973). Voltage laterality in the EEG of psychiatric patients. *Diseases of the Nervous System* 34, 190–191.
- Shagass, C., Roemer, R. A., Straumanis, J. J. & Amadeo, M. (1979). Evoked potential evidence of lateralized hemispheric dysfunction in the psychoses. In *Hemisphere Asymmetries of Function in Psychopathology* (ed. J. H. Gruzeliel and P. Flor-Henry), pp. 293–316. Elsevier/North Holland Biomedical Press: Amsterdam.
- Shagass, C., Roemer, R. A., Straumanis, J. F. & Amadeo, M. (1980). Topography of sensory evoked potentials in depressive disorders. *Biological Psychiatry* 15, 183–207.
- Shaw, J. C., Brooks, S., Colter, N. & O'Connor, K. P. (1979). A comparison of schizophrenic and neurotic patients using EEG power and coherence spectra. In *Hemisphere Asymmetries of Function in Psychopathology* (ed. J. H. Gruzeliel and P. Flor-Henry), pp. 257–284. Elsevier/North Holland Biomedical Press: Amsterdam.
- Sparks, R. & Geschwind, N. (1968). Dichotic listening in man after section of neocortical commissures. *Cortex* 4, 3–16.
- Taylor, P. J., Dalton, R. & Fleminger, J. J. (1980). Handedness in schizophrenia. *British Journal of Psychiatry* 136, 375–383.
- Tress, K. H., Kugler, B. T. & Caudrey, D. J. (1979). Inter-hemispheric integration in schizophrenia. In *Hemisphere Asymmetries of Function in Psychopathology* (ed. J. H. Gruzeliel and P. Flor-Henry), pp. 449–462. Elsevier/North Holland Biomedical Press: Amsterdam.
- Uherik, A. (1975). Interpretations of bilateral asymmetry of bioelectrical skin reactivity in schizophrenics. *Studia Psychologica* 17, 51–59.
- Venables, P. H. (1980). Primary dysfunction and cortical lateralisation in schizophrenia. In *Functional States of the Brain: Their Determinants* (ed. M. Kkou-Lehmann), pp. 243–264. Elsevier/North Holland Biomedical Press: Amsterdam.

- Wahl, O. F. (1976). Handedness in schizophrenia. *Perceptual and Motor Skills* 42, 944–946.
- Weller, M. & Kugler, B. T. (1979). Tactile discrimination in schizophrenic and affective psychoses. In *Hemisphere Asymmetries of Function in Psychopathology* (ed. J. H. Gruzelier and P. Flor-Henry), pp. 463–474. Elsevier/North Holland Biomedical Press: Amsterdam.
- Weller, M. & Montague, J. D. (1979). Electroencephalographic coherence in schizophrenia: a preliminary study. In *Hemisphere Asymmetries of Function in Psychopathology* (ed. J. H. Gruzelier and P. Flor-Henry), pp. 285–292. Elsevier/North Holland Biomedical Press: Amsterdam.
- Wexler, B. F. & Heninger, G. R. (1979). Alterations in cerebral laterality in acute psychotic illness. *Archives of General Psychiatry* 36, 278–284.
- Wing, J. K., Cooper, J. E. & Sartorius, N. (1974). *The Measurement and Classification of Psychiatric Symptoms*. Cambridge University Press: Cambridge.
- Yeudall, L. T. & Fromm-Auch, D. (1979). Neuropsychological impairments in various psychopathological populations. In *Hemisphere Asymmetries of Function in Psychopathology* (ed. J. H. Gruzelier and P. Flor-Henry), pp. 401–428. Elsevier/North Holland Biomedical Press: Amsterdam.
- Zangwill, O. L. (1960). *Cerebral Dominance and its Relation to Psychological Function*. Oliver and Boyd: Edinburgh.