Brit. J. Psychiat. (1983), **142,** 53–59

Phoneme Discrimination in Schizophrenia

BARBARA T. KUGLER and DAVID J. CAUDREY

Summary: Ear differences on a task involving a simple phonetic judgement were investigated in schizophrenic subjects using both healthy normal and depressed patient control groups. A deficit in phonemic differentiation was demonstrated and appeared to be specific to the schizophrenic group. The result is interpreted as supporting the hypothesis of a central dysfunction lateralized to the left hemisphere in schizophrenia.

Despite the general tendency for linguistic processing to be lateralized to the left, or dominant, hemisphere, dominance does not apply equally to all aspects of speech or to all speech sounds (Brown and Deffenbacher, 1979). Stop consonants appear to show most lateralization, and phonemes comprising a stop consonant plus vowel (/pa/, /ba/, /ta/, /da/, /ka/, /ga/) have been used extensively in dichotic listening studies to elicit the well-documented 'right-ear advantage' (REA) ascribed to the presumed left hemisphere dominance for speech (e.g. Berlin and McNeil, 1976; Berlin, 1977).

Luria (1973) has reported that disturbances of phonemic hearing are found in patients with left, but not right, temporal lobe lesions and that loss of the ability to distinguish between closely sounding phonemes leads to difficulty both in the understanding of spoken speech and in the production of coherent speech. The frequent occurrence of such symptoms in schizophrenic patients (e.g. Cohen, 1978; Bruder and Yozawitz, 1979; Caudrey and Kirk, 1979) supports the hypothesis of a lateralized central dysfunction in schizophrenia involving the left temporal lobe and the temporal-limbic system (see Gruzelier and Flor-Henry, 1979; Gruzelier, 1981).

Procedures that require subjects to report simultaneously presented dichotic stimuli involve a memory load and attentional conflict, and disturbances in these processing functions may underly deficits in perceptual discrimination in schizophrenic patients (Caudrey and Kirk, 1979).

Despite the suggestion that dichotic presentation is necessary if laterality effects are to be obtained (e.g. Kimura, 1964), clear effects have been shown with monaural presentation and it has been claimed that the same cerebral mechanisms are revealed by the monaural and dichotic methods (Kallman, 1977). Morais and Darwin (1974) showed that ear differences can be detected with monaural presentation of stimuli when the task involves remembering a previously presented phoneme and comparing it with a second phoneme in terms of its categorization as 'same' or 'different'. Furthermore, the task has been shown to elicit an REA even when the subjects are aware to which ear the second phoneme is presented (Morais, 1975), making an explanation in terms of attention bias unlikely.

This simple phonetic task was chosen to investigate perceptual discrimination ability in schizophrenic patients. As performance by both ears is worse under dichotic than under monaural conditions (Berlin, 1977), it was hoped that a monaural task would minimize the expected general performance decrement encountered in testing pathological populations (e.g. Caudrey and Kirk, 1979; Schwartz, 1978). While it is well documented that the performance of schizophrenic patients fails to match that of control subjects, the location of this deficit is still unclear. The influence of medication, for example, has to be considered when relative information-processing speed is investigated (Schwartz, 1978) and provision was made, in the present research, for correcting reaction times (for same or different judgements) for movement.

Two control groups were included in this study of phoneme discrimination ability in schizophrenia. Normal volunteer subjects formed a replication group for the Morais and Darwin (1974) results. A depressed patient group was included on the expectation that, if depression, unlike schizophrenia, is associated with right-hemisphere dysfunction (e.g. Gruzelier and Flor-Henry, 1979), a deficit in phonemic differentiation found only in the schizophrenic subject group would relate to a specific pathology, whereas a performance deficit shared by both psychiatric groups could reflect a failure of task involvement, or motivation, rather than a failure of perceptual discrimination.

https://doi.org/10.1192/bjp.142.1.53 Published online by Cambridge University Press

Subjects were presented with two successive phonemic stimuli (consonant–vowel syllables, differing or not in the consonant), the first binaurally and the second to the left or right ear only in an unpredictable manner. Immediately after presentation of each pair, the subject responded with a simple key press indicating whether the stimuli were the same or different. While the concurrent memory load in the task is sufficient to increase the likelihood that slight differences between contralateral and ipsilateral cortical representation (e.g. Rosenzweig, 1951; Vaughn and Ritter, 1970) will lead to detectable performance differences (Morais and Darwin, 1974), the involvement of memory is minimal. Furthermore, as there is evidence that short-term memory processes in schizophrenic patients are intact (e.g. Koh, 1978), any observed deficit could be attributable to a speech perception deficit.

Subjects

Three groups of subjects participated in the study. Originally, there were 14 subjects in each group. All the patients were hospitalized and were tested on the basis of hospital diagnoses. Extensive case-note summaries were made at the time of testing and, whenever possible, the case-note syndrome checklist of the Present State Examination (Wing *et al*, 1974) was used to confirm diagnosis.

All 14 patients in the 'schizophrenic' group were categorized as schizophrenic (S+) on the case-note syndrome checklist, and also met Feighner's diagnostic criteria for schizophrenia (Feighner *et al*, 1972). However, three subjects were unable to comprehend the nature of the task and responded on more than 95 per cent of the trials with the 'same' response. These patients were excluded from the schizophrenic group. The mean age of the 11 remaining schizophrenic subjects was 35.87 years (range: 17–56 years). The mean duration of illness was 10.0 years (range: two months to 27 years) and the mean age at onset of the illness was 25.9 years (range: 17–35 years). These patients were all receiving major tranquillizer medication with an average dose, expressed as the chlorpromazine equivalent (Freedman *et al*, 1976; Hollister, 1978), of 455 mg/day (range: 60–900 mg/day).

Case-note examination of the 14 'depressed' subjects disclosed that only seven patients unambiguously met Feighner's criteria for a primary affective disorder of depression. In addition, two of these seven 'depressed' patients met the Present State Examination requirements for the D+ categorization (psychotic depression). The remaining seven subjects showed signs of mania or 'schizophreniform'/'atypical' psychosis, and were therefore excluded from the 'depressed' group in order to maximize the diagnostic homogeneity within groups. Although these exclusions very much reduced the size of the depressed control group, recent work has emphasized that the low reliability for differential diagnosis of non-schizophrenic psychoses may lead to important contrasts between schizophrenia and other psychoses being obscured rather than clarified (Ritzler and Rinehart, 1981). Failure to control for psychosis in studies of schizophrenia, on the other hand, leaves several important questions unanswered.

The mean age of the seven depressed patients whose results were analysed was 39.43 years (range: 20–60 years.) The mean duration of illness was 6.75 years (range: three months to 16 years), and the mean age of onset was 32.71 years (range: 20–44 years). Three of these patients were receiving major tranquillizer medication with an average dose, expressed as the chlorpromazine equivalent, of 300 mg/day (range: 200–400 mg/day.) Three of the patients were receiving antidepressant medication with an average dose, expressed as the amitriptyline equivalent (Freedman *et al*, 1976; Hollister, 1978), of 175 mg/day (range: 100–225 mg/day.) One patient was receiving lithium as the sole form of medication.

The average age of the 14 healthy volunteer control subjects was 33.79 years (range: 20–49 years).

All subjects were right-handed, as assessed by the six primary items of the Annett questionnaire (Annett, 1970).

Apparatus and stimuli

As Morais and Darwin (1974) found that chance error scores were obtained on both ears when stimuli differed only by voicing, whereas an REA was obtained when stimuli differed by place and voice, only the latter type of phonemes (/ba/, /da/, /ga/) were used in the present study.

Each trial consisted of the presentation of a pair of computer-synthesized consonant–vowel syllables of 200 msec duration and with a 300-msec gap between the end of the first item of the pair and the onset of the second. Two cassette tapes were used with 63 syllable pairs recorded on each. The first three pairs on each tape were included solely for practice and were excluded from subsequent data analysis. Thirty pairs consisted of syllables with the same initial stop consonant (ten each of /ba/-/ba/, /da/-/da/ and /ga/-/ga/) while the other 30 consisted of syllables with different initial stop consonants (five each of /ba/-/da/, /ba/-/ga/, /da/-/ga, /da/-/ba/, /ga/-/ba/ and /ga/-/da/). A 1000-Hz pure-tone warning stimulus of 100 msec duration occurred 600 msec prior to the onset of the first item of each pair. There was a 1.5-sec gap between the end of

https://doi.org/10.1192/bjp.142.1.53 Published online by Cambridge University Press

the second item of the pair and the onset of the next warning signal.

To increase the chances of showing a right-ear advantage, paired sounds were presented at different pitches. The first syllable was recorded at a pitch of 100 Hz on both tracks of the cassette and was delivered to both ears. The second syllable was recorded at 161 Hz on only one track (randomly either on track 1 or on track 2) and was delivered to either the left or the right ear. Approximately equal numbers of left- and right-ear presentations occurred for each of the three possible 'same' pairs and six possible 'different' pairs. All syllable combinations were randomized, recorded on BASF Chromdioxid tape and played to the subjects on a Sony TC-153SD stereo cassette recorder over AD-11 headphones.

The warning signal preceding each syllable pair triggered a Forth Instrument digital timer, which was stopped by the subject pressing one of two buttons. Reaction time was measured to the nearest millisecond and the experimenter recorded the response made and the reaction time before resetting the timer. The experimenter used the pause button on the recorder to delay the start of the next trial if necessary.

Procedure

Each subject was played two tapes, each of 63 syllable pairs. For tape 1, the subject's task was to decide as quickly as possible whether the second syllable was the same as the first or different. Half the subjects in each group were instructed to press the left-hand button to indicate a 'same' judgement and the right-hand button to indicate a 'different' judgement. For the other subjects the button allocation was reversed.

For tape 2, the subject's task was to press the button on the side coresponding to the ear in which the second syllable was presented, regardless of stimulus type. This comparison task permits a measure of movement time for each subject so that speech-processing time can be assessed uncontaminated by factors associated with general psychomotor slowing.

Half the subjects in each group received tape 1 first, and half tape 2 first. Subjects were seated in a sound-attenuated room and instructed to press the appropriate button as soon as possible while trying to be accurate in their choice of buttòn. Each subject attended for only one session and each session took about 45 minutes.

Results

For comparability, the results of the present study are analysed following the procedure adopted by Morais and Darwin (1974). In line with the previous study, separate analyses of variance are performed for 'same' and 'different' responses following an initial analysis that included type of response as a factor.

Reaction times

Movement times in response to the side (ear) of stimulus presentation were analysed by a three-way analysis of variance including group (schizophrenic *vs.* depressed *vs.* normal), ear (left *vs.* right) and type of response ('same' *vs.* 'different'). Type of response was included despite the instruction to ignore the stimuli to check that subjects complied with instructions. The analysis revealed a main effect of group ($F = 10.25$, d.f. $= 2,29$, $P < 0.001$), but no other significant main or interaction effects. *Post hoc* comparisons (Scheffé: cf. Winer, 1971, p 198) confirmed longer movement times for both patient groups as compared to normal subjects ($P < 0.005$ for the schizophrenic group, $P < 0.01$ for the depressed group), but no significant differences were found between the patient groups. No errors were made on this task and the mean correct movement times in milliseconds for the three groups were as follows: normal subjects 1,651 msec, depressed subjects 1,964 msec, schizophrenic subjects 2,012 msec.

Reaction times to the 'same'–'different' judgement task were corrected for each subject by subtracting movement times from task reaction times. These adjusted mean RTs (for correct responses, in milliseconds) for the three subject groups are shown in Table I.

An initial three-way analysis of variance on these data, (including group, ear and type of response) showed that 'same' responses tended to be faster than 'different' responses ($F = 4.01$, d.f $= 1,29$, $P = 0.055$), replicating the Morais and Darwin (1974) finding (which was also at the $P < 0.1$ level). The main effect of group was significant ($F = 5.23$, d.f. $= 2,29$, $P < 0.012$), and comparison of the schizophrenic group with each of the two control groups (using Dunnett's method: c.f. Winer, 1971, p 201) showed that mean correct RTs for the schizophrenic subjects were significantly longer than those for normal ($P < 0.005$) and for depressed ($P < 0.025$) subjects. The group×ear interaction was also significant ($F = 3.87$, d.f. $= 2,29$, $P < 0.033$), and *post hoc* comparisons (Scheffé)showed faster left- than right-ear RTs for schizophrenic subjects ($P < 0.005$), with no significant ear differences for either the healthy control or the depressed groups.

In line with the Morais and Darwin(1974) procedure, two separate two-way analyses of variance (group and ear) were performed, one for the 'same' RTs, the other for the 'different' RTs. A main effect of ear was significant for the 'same' response ($F = 10.44$, d.f. $= 1,29$, $P < 0.004$) with faster left- than right-ear RTs.

https://doi.org/10.1192/bjp.142.1.53 Published online by Cambridge University Press

TABLE I

Mean Correct Reaction Times by type of response and by ear

	Same						Different					
	Left ear			Right ear			Left ear			Right ear		
	Mean RT	SD	Errors (%)	Mean RT	SD	Errors (%)	Mean RT	SD	Errors (%)	Mean RT	SD	Errors (%)
Schizophrenic subjects	567	503	37.1	814	552	30.1	865	686	44.4	927	551	43.0
Normal subjects	319	175	25.5	342	179	25.5	372	204	40.5	318	205	31.1
Depressed subjects	340	335	8.0	368	333	11.2	415	345	46.7	337	259	40.0

All values in milliseconds with standard deviations and percentage errors.

However, the group×ear interacton was also significant ($F = 5.73$, d.f. = 2,29, $P < 0.008$) and *post hoc* comparisons (Scheffé) indicated that the former result was attributable to the performance of the schizophrenic subjects who showed a highly significant left-ear advantage of 247 msec ($P < 0.001$). Ear differences for the 'same' response were not found for either control group, again replicating the Morais and Darwin finding for normal subjects. The former authors' finding of statistically significant faster RTs for the 'different' response when the second syllable was presented in the right ear than when it was presented in the left, was not replicated with the present normal group. Nevertheless, the results were in the expected direction (see also Laterality Effects below), with right-ear responses being 54 msec faster than left. The results of the depressed group were similar to those of the normal group (with a 78 msec REA), whereas those of the schizophrenic group differed in showing a 62 msec left-ear advantage.

The main effect of group was significant for the 'different' response ($F = 6.61$, d.f. = 2,29, $P < 0.005$), with schizophrenic subjects showing longer RTs than either normal ($P < 0.005$) or depressed ($P < 0.01$) subjects (Dunnett's comparisons). For the 'same' response, the group main effect fell short of significance ($F = 3.15$, d.f. = 2,29, $P < 0.06$). While the difference between the schizophrenic and normal groups was significant ($P < 0.025$), that between the schizophrenic and depressed groups was not.

Errors

Percentage error scores were analysed in the same way as mean correct RTs. The three-way analysis of variance (group, ear and type of response) revealed no significant main effect of group, indicating that the overall accuracy of performance was similar for all subjects. In line with the Morais and Darwin (1974) finding there were more errors for the 'different' response than for the 'same' response ($F = 12.67$, d.f. = 1,29, $P < 0.002$), and this finding was consistent across all three subject groups.

Separate analyses for 'same' and 'different' errors revealed a significant main effect of group for 'same' errors only ($F = 4.10$, d.f. = 2,29, $P < 0.03$). More errors were made by the schizophrenic patients than by the depressed patients ($P < 0.025$, Dunnett) but there was no difference in performance between the schizophrenic and the normal subjects. Planned orthogonal comparisons (cf. Winer, 1971, p 172) testing the prediction of more left- than right-ear errors for 'different' responses (Morais and Darwin, 1974) confirmed the prediction only for normal subjects ($P < 0.05$). No ear differences were found in the patient groups.

https://doi.org/10.1192/bjp.142.1.53 Published online by Cambridge University Press

Laterality effects

The tendency to report laterality effects in terms of the mean difference between left and right ears rather than in terms of the proportion of subjects showing right-ear superiority has been raised in the literature, and it is claimed that 'both sets of data are required for a clear understanding of the processes involved' (Bryden and Allard, 1978). Accordingly, the proportion of subjects showing an REA for mean correct RTs and percentage errors, divided according to type of response, is given in Table II.

In line with the expectations from the Morais and Darwin (1974) study, a significant REA for 'different' judgements was found for mean correct RTs in the normal subject group (P = 0.029; Sign test, Siegel 1956). The only other significant result was the finding of a right-ear disadvantage for mean correct RTs for 'same' judgements in the schizophrenic group (P = 0.006; two-tailed, Sign test, Siegel, 1956)

Medication

It was not possible to withhold patients' medication, although it was possible to look at correlations between dose of phenothiazines and error scores, and between dose and RTs in the schizophrenic group.No significant correlations were found (Spearman). In the depressed group, medication was too variable for such comparisons to be made.

Discussion

The results of the present study support the Morais and Darwin (1974) conclusion that ear differences can be detected on a simple perceptual task even with monaural stimulus presentation. These authors reported that normally a right-ear advantage (REA) in reaction times is obtained for 'different' but not for 'same' judgements, and that for 'different' judgements only, significantly fewer errors are made when the second phoneme comes to the right rather than to the left ear. The results of the normal subject group (our 'replication' group) substantiate these findings.

TABLE II

Percentages of subjects with a right ear advantage (REA) for mean correct reaction time and percentage errors divided according to type of response

	Same		Different	
	RT	Erors	RT	Errors
Schizophrenic subjects	9*	55	45	36
Normal subjects	43	43	79**	57
Depressed subjects	43	29	57	71

* P = 0.006, ** P = 0.029.

Morais and Darwin suggest that, although the two sounds the subjects were comparing differed in pitch so that a template type of match (in terms of the physical properties of the stimulus and without recourse to category names) could not be made at the level of the wave form, a template match in terms of formant frequencies might provide an interpretation of why ear differences only appear in the 'different' judgements. This implies that the two hemispheres differ more in their ability to make a categorical match (involving comparisons between stimulus category names) than in their ability to make a template match. The right hemisphere, as compared with the left, thus shows inferior performance on the former task and equal (or superior) performance (e.g. Cohen, 1972; Geffen *et al*, 1972) on the latter. The present results are consistent with this implication.

It has been suggested that error scores reflect degradation of information as it passes from a non-competent to a competent hemisphere. Ear differences in RT may involve transcallosal transmission time, but are also thought to reflect the efficiency of an attention-switching mechanism determined by sequential rather than simultaneous arousal or attentiveness of the two hemispheres (Levy, 1974; Kinsbourne, 1970). In terms of error scores, no laterality differences were found in any subject group for 'same' judgements and an REA was obtained for 'different' judgements only in the normal subject group. However, while the schizophrenic group showed no evidence of ear dominance effects (either in terms of the mean difference between left and right ears, or in terms of the proportion of subjects showing superior right-ear performance), the results of the depressed group were in the same direction as those of the normal group. As the overall number of errors for 'different' judgements was comparable in all three subject groups, the schizophrenic subjects showed an absence of the expected REA rather than a general performance deficit.

In terms of reaction time, schizophrenic subjects were generally slower in making simple phonetic judgements than either control group, and this performance deficit was most marked when the second phoneme came to the right rather than to the left ear. For 'same' judgements, in line with expectations no ear dominance effects were found in the control groups but a strong left-ear advantage was evident in the schizophrenic group. While supporting the view that such judgements may be made on the basis of some type of template match for which higher-level left hemisphere categorical processing is not essential, these results

https://doi.org/10.1192/bjp.142.1.53 Published online by Cambridge University Press

also raise the possibility that subjects with no left-hemisphere dysfunction may, nevertheless, use category names as an aid to performance.

Whereas the schizophrenic subjects showed less disturbance of phonemic hearing than Luria's patients, Noffsinger and Kurdziel (1979) have concluded on the basis of auditory test results with cortical lesion patients that left temporal lobe damage decreases right-ear performance or the performance of both ears on tasks which, on average, show an REA in normal subjects. The present results are, therefore, consistent with the hypothesis of a left hemisphere dysfunction in schizophrenia.

This 'laterality' hypothesis of schizophrenia (Flor-Henry, 1969, 1979), formulated on the basis of the association of schizophrenic symptomatology with epilepsy and organic lesions of the dominant temporal lobe and concordant with the disturbances of language and auditory functions characteristic of the disorder, has been supported by evidence from psychophysiological, electroencephalographic and experimental psychological studies (see Gruzelier and Flor-Henry, 1979). More complex models of hemisphere asymmetries of function in psychopathology are being postulated, but continue to support the view that the primary disturbance in schizophrenia is likely to arise in the left, or dominant, hemisphere (see Gruzelier, 1981).

The left hemisphere plays a greater role in speech-processing than the right (e.g. Kimura, 1961a, 1961b; Springer,1977) and, in addition to experimental data, there is clinical evidence for a speech perception deficit in schizophrenia. For example, patients are reported as saying, 'When people talk to me it's like a different kind of language', or 'I have to pay all my attention to people when they are speaking, otherwise I get all mixed up and don't understand them' (Lawson *et al*, 1964). It is still not clear at what level such speech-processing difficulties arise, but a basic difficulty at the level of phoneme discrimination would clearly contribute to deficiencies in speech production and perception.

Throughout the present study, when laterality effects were considered both in terms of the mean group differences between left and right ears and in terms of the proportion of subjects showing right-ear superiority in task performance, the results of the depressed patient group were in the same direction as those of the normal group. The performance of the schizophrenic subjects differed from both control groups despite the previously reported similarity between depressed and schizophrenic subjects in error incidence on a somewhat similiar task (Caudrey and Kirk, 1979). This difference in performance, suggested in the present analysis of error scores, is substantiated by the RT findings. In the latter, the difference in results between schizophrenic and depressed subjects appears to arise from the correction procedure (for movement times) employed in the present study and implies that, whereas a general speed-of-performance deficit may be shared by the two psychiatric groups, the deficit in phonemic differentiation is confined to the schizophrenic subjects. The importance of establishing adequate criteria for speed of information-processing comparisons across different subject groups is emphasized by these findings.

Acknowledgements

We thank Mr Peter Howell of the Psychology Department, University College London for preparing the stimulus tapes used in this experiment and Dr T. Naidoo for assisting with testing. We acknowledge the financial support of the Sir Jules Thorn Medical Research Endowment Trust.

References

ANNETT, M. (1970) A classification of hand preference by association analysis. *British Journal of Psychology*, **61**, 303–21.

BERLIN, I.C. (1977) Hemisphere asymmetry in auditory tasks. In *Lateralisation in the Nervous System* (eds. S. Harnad, R. W. Doty, L. Goldstein, J. Jaynes and G. Krauthamer), pp 303–23. New York: Academic Press.

—— & MCNEIL, M. (1976) Dichotic listening. In *Contemporary Issues in Experimental Phonetics* (ed. N. Lass), pp 327–87. New York: Academic Press.

BROWN, E. L. & DEFFENBACHER, K. (1979) *Perception and the Senses*. New York: Oxford University Press.

BRUDER, G. E. & YOZAWITZ, A. (1979) Central auditory processing and lateralisation in psychiatric patients. In *Hemisphere Asymmetries of Function in Psychopathology* (eds. J. H. Gruzelier and P. Flor-Henry), pp 561–80. Amsterdam: Elsevier/North-Holland Biomedical Press.

BRYDEN, M. P. & ALLARD, F. (1978) Dichotic listening and the development of linguistic processes. In *Asymmetrical Function of the Brain* (ed. M. Kinsbourne) pp 392–404. Cambridge: Cambridge University Press.

CAUDREY, D. J. & KIRK, K. (1979) The perception of speech in schizophrenia and affective disorders. In *Hemisphere Asymmetries of Function in Psychopathology* (eds. J. H. Gruzelier and P. Flor-Henry), pp 581–601. Amsterdam: Elsevier/North-Holland Biomedical Press.

COHEN, B. D. (1978) Referent communication disturbances in schizophrenia. In *Language and Cognition in Schizophrenia* (ed. S. Schwartz), pp 1–34. Hillsdale, New Jersey: Lawrence Erlbaum Associates.

COHEN, G. (1972) Hemispheric differences in a letter classification task. Perception and Psychophysics, **11**, 139–42.

FEIGHNER, J. P., ROBINS, E., GUZE, S. B., WOODRUFF, R. A., WINOKUR, G. & MUNOZ, R. (1972) Diagnostic criteria for use in psychiatric research. *Archives of General Psychiatry*, **26**, 57–63.

FLOR-HENRY, P. (1969) Psychosis and temporal lobe epilepsy: a controlled investigation. *Epilepsia*, **10**, 363–95.

https://doi.org/10.1192/bjp.142.1.53 Published online by Cambridge University Press

—— (1979) Laterality, shifts of cerebral dominance, sinistrality and psychosis. In *Hemisphere Asymmetries of Function in Psychopathology* (eds. J. H. Gruzelier and P. Flor-Henry), pp 3–19. Amsterdam: Elsevier/North-Holland Biomedical Press.

FREEDMAN, A. M., KAPLAN, H. I. & SADOCK, B. J. (1976) *Modern Synopsis of Psychiatry/II*. Baltimore: Williams and Wilkins.

GEFFEN, G., BRADSHAW, J. L. & NETTLETON, N. C. (1972) Hemispheric asymmetry: Verbal and spatial encoding of visual stimuli. *Journal of Experimental Psychology*, **95**, 25–31.

GRUZELIER, J. H. (1981) Cerebral laterality and psychopathology: fact and fiction. Editorial. *Psychological Medicine*, **11**, 219–27.

—— & FLOR-HENRY, P. (1979) *Hemisphere Asymmetries of Function in Psychopathology*. Amsterdam: Elsevier/North-Holland Biomedical Press.

HOLLISTER, L. E. (1978) *Clinical Pharmacology of Psychotherapeutic Drugs*. New York: Churchill-Livingstone.

KALLMAN, H. J. (1977) Ear asymmetries with monaurally-presented sounds. *Neuropsychologia*, **15**, 833–5.

KIMURA, D. (1961a) Some effects of temporal-lobe damage on auditory perception. *Canadian Journal of Psychology*, **15**, 156–65.

—— (1961b) Cerebral dominance and the perception of verbal stimuli. *Canadian Journal of Psychology*, **15**, 166–71.

—— (1964) Left-right differences in the perception of melodies. *Quarterly Journal of Experimental Psychology*, **16**, 355–8.

KINSBOURNE, M. (1970) The cerebral basis of lateral asymmetries in attention. *Acta Psychologica*, **33**, 193–201.

KOH, S. D. (1978) Remembering of verbal materials by schizophrenic young adults. In *Language and Cognition in Schizophrenia* (ed. S. Schwartz), pp 55–99. Hillsdale, New Jersey: Lawrence Erlbaum Associates.

LAWSON, J. S., MCGHIE, A. & CHAPMAN, J. (1964) Perception of speech in schizophrenia. *British Journal of Psychiatry*, **110**, 375–80.

LEVY, J. (1974) Psychobiological implications of bilateral asymmetry. In *Hemisphere Function in the Human Brain* (eds. S. J. Dimond and J. G. Beaumont), pp 121–83. London: Elek Science.

LURIA, A. R. (1973) *The Working Brain*. London: Allen Lane, Penguin.

MORAIS, J. (1975) Monaural speech differences for same-different reaction times to speech with prior knowledge of ear stimulated. *Perceptual and Motor Skills*, **41**, 829–30.

—— & DARWIN, C. J. (1974) Ear differences for same-different reaction times to monaurally presented speech. *Brain and Language*, **1**, 383–90.

NOFFSINGER, P. D. & KURDZIEL, S. A. (1979) Assessment of central auditory lesions. In *Hearing Assessment* (ed. W. F. Rintelmann), pp 351–77. Baltimore: University Park Press.

RITZLER, B. A. & RINEHART, K. (1981) Psychotic controls in schizophrenia research. *Schizophrenia Bulletin*, **7**, 729–35.

ROSENZWEIG, M. R. (1951) Representations of the two ears at the auditory cortex. *American Journal of Physiology*, **167**, 147–58.

SCHWARTZ, S. (1978) Language and cognition in schizophrenia: a review and synthesis. In *Language and Cognition in Schizophrenia* (ed. S. Schwartz), pp 237–76. Hillsdale, New Jersey: Lawrence Erlbaum Associates Inc.

SIEGEL, S. (1956) *Nonparametric Statistics for the Behavioural Sciences*. Tokyo: McGraw-Hill Kogakusha.

SPRINGER, S. P. (1977) Tachistoscopic and dichotic-listening investigations of laterality in normal human subjects. In *Lateralisation in the Nervous System* (eds. S. Harnad, R. W. Doty, L. Goldstein, J. Jaynes and G. Krauthamer), pp 325–36. New York: Academic Press.

VAUGHN, H. & RITTER, W. (1970) The sources of auditory evoked responses recorded from the human scalp. *Electroencephalography and Clinical Neurophysiology*, **28**, 360–7.

WINER, B. J. (1971) *Statistical Principles in Experimental Design*. 2nd edition. Tokyo: McGraw-Hill Kogakusha.

WING, J. K., COOPER, J. E. & SARTORIUS, N. (1974) *The Measurement and Classification of Psychiatric Symptoms*. Cambridge: Cambridge University Press.

Barbara T. Kugler, *Neuropsychology Research Unit, Friern Hospital, London N11 3BP; and Department of Clinical Pharmacology, University College London, Gower Street, London WC1E 6BT*

David J. Caudrey, *Regency Park Centre for Young Disabled, Days Road, Regency Park, South Australia 5010; and Department of Psychology, University of Adelaide, South Australia 5000*

(Received 1 June; revised 1 July 1982)

https://doi.org/10.1192/bjp.142.1.53 Published online by Cambridge University Press