

Cerebral Laterality and Psychopathology: A Review of Dichotic Listening Studies

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Abstract

Studies using dichotic listening tasks have reported findings suggestive of alterations of cerebral laterality in schizophrenia and affective disorders. In a review of these findings, an effort was made to take into account four factors: (1) type of dichotic listening task; (2) performance level; (3) clinical state of patients at the time of testing; (4) diagnostic subtype of patients. A convergence of evidence indicates that the last two factors are of major importance. Several studies have found a relationship between clinical state and dichotic ear asymmetry. Greater severity of illness in schizophrenic and depressed patients is associated with reduced laterality, and clinical remission is accompanied by a normalization of laterality. While this relationship appears to hold for both verbal and nonverbal dichotic tasks in depressed patients, that is not the case for schizophrenic patients. Studies have also reported evidence of differences in dichotic ear asymmetry between diagnostic subtypes of schizophrenia (i.e., paranoid vs. nonparanoid patients) and affective disorders (i.e., bipolar vs. unipolar patients). This evidence suggests the existence of homogeneous subgroups with distinctive laterality patterns and clinical characteristics.

Several articles have reviewed evidence that generally favors hypotheses of left hemisphere involvement in schizophrenia and right hemisphere involvement in affective disorders (Flor-Henry 1976; Wexler 1980; Newlin, Carpenter, and Golden 1981; Tucker 1981). In these global reviews where the emphasis is on integrating findings across numerous studies using a wide variety of direct and indirect measures of cerebral asymmetry (e.g., neuropsychological tests, dichotic listening, lateral eye move-

ments, skin conductance responses, the electroencephalogram, computed tomography, and regional cerebral blood flow), important details concerning the findings for specific measures are sometimes omitted or are not given adequate attention. The purpose of this review is to focus on studies that have used dichotic listening techniques in which the target stimuli (e.g., words, nonsense syllables, music, and clicks) were presented at approximately the same time to the two ears. One aim is to highlight some methodological and theoretical issues that are of importance not only for studies of laterality and psychopathology that use dichotic listening tasks but also studies using other measures of cerebral asymmetry. A second aim is to review the convergence of evidence that is beginning to emerge, which indicates that alterations in dichotic ear asymmetry in schizophrenia and affective disorders are related both to the patient's specific diagnostic subtype and to the severity of the patient's clinical state.

Dichotic Listening as an Index of Hemispheric Asymmetry

It is well known that monaural input to either ear is represented in both cerebral hemispheres, with a small advantage for contralateral over ipsilateral ear-to-hemisphere pathways (Rosenzweig 1951; Hall and Goldstein 1968). When different stimuli are presented simultaneously to the two ears in a dichotic listening task, the weaker ipsilateral pathways are thought to be suppressed by the stronger contralateral pathways. The

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primary evidence for this comes from studies that have tested commissurotomy patients in dichotic listening tasks (Milner, Taylor, and Sperry 1968; Sparks and Geschwind 1968; Springer and Gazzaniga 1975). These patients have no difficulty reporting words or consonant-vowel syllables presented monaurally to either ear, but when the same stimuli are presented dichotically, they fail to report items presented to the left ear. The lesioning of the corpus callosum prevents the input in the left ear from reaching the left hemisphere via the indirect contralateral route that goes initially to the right hemisphere and then crosses the callosal pathways. This indirect contralateral route permits normal subjects to hear dichotic items in both ears, with a small advantage favoring the ear contralateral to the dominant hemisphere.

Evidence for the validity of dichotic ear asymmetry¹ as an index of language dominance is found in studies that used invasive procedures (Wada Test or unilateral electroconvulsive therapy) to determine the hemisphere dominant for speech (Kimura 1961a; Geffen and Caudrey 1981). Although even the most reliable dichotic word or nonsense syllable tests would be expected to misclassify some individual as to the hemisphere dominant for speech, the findings of the above studies suggest that individual differences in the direction of ear asymmetry are related to cerebral lateralization. Moreover, there is increasing recognition that differences in the *magnitude* of ear asymmetry among individuals are an important aspect of dichotic listening

performance and that these differences are, at least in part, related to individual variations in the degree of cerebral lateralization (Shankweiler and Studdert-Kennedy 1975; Repp 1977; Lauter 1982).

Dichotic listening studies of cerebral laterality in schizophrenia and affective disorders can, therefore, provide information as to whether these disorders are characterized by alterations of the normal "dominance effects." For instance, do schizophrenic patients show the expected right ear advantage for verbal dichotic tasks, and is the magnitude of the ear advantage equal to that found for normal subjects? If schizophrenia or affective disorders involve lateralized cerebral dysfunctions that impinge upon the central auditory nervous system, one would expect to find abnormal dichotic ear asymmetry.

One possibility is that psychiatric patients will display the "lesion effects" found for neurological patients with unilateral temporal lobe lesions. These "lesion effects" refer to the decrement in performance seen for the ear contralateral to the lesioned hemisphere (Kimura 1961b; Schulhoff and Goodglass 1969; Hosokawa, Shibuya, and Hosokawa 1978). A bilateral decrement in performance on verbal dichotic tasks occurs in patients with left temporal lesions, but a larger impairment is typically seen for the right ear and, as a result, patients with left temporal lesions show either no right ear advantage or even a left ear advantage. In contrast, right temporal lesions commonly result in almost total extinction of dichotic items presented to the left ear, while performance for items presented to the right ear may be equal to or better than seen for normal subjects. An abnormally large right ear advantage could, however, stem not only from right temporal pathology but also from damage to any

portion of the interhemispheric pathway (e.g., Damasio and Damasio 1979). Thus, "paradoxical" left ear extinction has been found to occur with lesions of the interhemispheric auditory pathways in the parieto-occipital region of the left hemisphere. Such "paradoxical effects" in neurological patients point to the need for caution in interpreting dichotic listening findings for psychiatric patients. The use of both verbal and nonverbal dichotic listening tests, as well as other tests of left and right hemisphere function that do not depend on interhemispheric transfer (Wexler 1980), can provide converging lines of evidence to help resolve this interpretive problem.

Another possibility is that abnormalities of dichotic ear asymmetry displayed by psychiatric patients are more subtle and transient than the "lesion effects" seen for neurological patients. This could occur if schizophrenia or affective illness involved alterations in the relative balance of left-right hemispheric activation (Kinsbourne 1970). For instance, during illness there could be overactivation of one hemisphere, while following recovery the balance of hemispheric activity could return to normal. Although it may often be difficult using dichotic listening measures alone to differentiate between "lesion effects" and alterations in the balance of hemispheric activity, studies that test psychiatric patients both during their illness and following clinical recovery are of value here (e.g., Wexler and Heninger 1979; Johnson and Crockett 1982).

Verbal Dichotic Tasks

A number of different dichotic listening tasks have been used to measure language laterality in psychiatric patients (see table 1). The tasks consist of presenting a different word, digit,

¹ The term "ear asymmetry" is generally used to refer to the empirical difference in performance for material presented to the right and left ears.

or nonsense syllable at the same time to the two ears. Although the different tasks have consistently yielded a mean right ear (left hemisphere) advantage for groups of normal right handed subjects, the average magnitude of the right ear advantage has been found to vary from about 5 to 15 percent. Since dichotic tasks that differ in acoustic content, memory

load, and response format may tap different aspects of information processing and laterality (Berlin and McNeil 1976), the findings for the various verbal dichotic tasks will be presented in separate sections and attention will be given to specific task characteristics that are important for interpreting dichotic listening findings with psychiatric patients.

Dichotic Recall Tasks. The first five studies listed in table 1 used similar dichotic recall tasks in which three pairs of digits or other monosyllabic words are presented to the two ears and the subject reports what was heard. The dichotic recall task provides a measure of ear asymmetry that has been reported to reflect hemispheric dominance for language

Table 1. Dichotic listening in schizophrenia and affective disorders: Verbal tasks

Study	Task	Subjects	Findings
Lerner, Nachshon, and Carmon (1977)	Dichotic digits (free recall)	60 Schizophrenics 20 Normals	Right ear advantage greatest in paranoids, intermediate in non-paranoids, and smallest in normals
Lishman et al. (1978)	Dichotic words (free recall)	15 Schizophrenics 13 Affective psychotics (most had manic features) 15 Normals	Right ear advantage greater in both patient groups compared to normals
Gruzeller & Hammond (1980)	Dichotic digits (directed and free recall)	18 Schizophrenics 16 Normals	Right ear advantage same for patients and normal groups, but greater in paranoids compared to nonparanoids
Goode, Manning, & Middleton (1981)	Dichotic words (free recall)	13 Schizophrenics 20 Schizoaffectives 36 Normals	Right ear advantage same for patient and normal groups
Johnson & Crockett (1982)	Dichotic words (free recall)	16 Schizophrenics 16 Unipolar depressives 16 Normals	Both patient groups failed to show a right ear advantage
Yozawitz et al. (1979)	Dichotic words (SSW Test)	10 Schizophrenics 9 Affective psychotics (most had manic features) 10 Normals	Affective psychotics showed an abnormal right ear advantage, whereas schizophrenics did not
Colbourn & Lishman (1979)	Dichotic consonant-vowel syllables	16 Schizophrenics 10 Affective psychotics 13 Nonpsychotic controls 19 Normals	All groups but the schizophrenics showed a right ear advantage
Wexler & Heninger (1979)	Dichotic vowel-consonant-vowel syllables	8 Schizophrenics 6 Schizoaffectives 12 Affective psychotics 23 Normals	No difference in ear asymmetry for patient and control groups
Moscovitch, Strauss, & Olds (1981)	Dichotic consonant-vowel syllables	7 Unipolar depressives	Unipolars failed to show a right ear advantage

processing (Kimura 1961a). Since a total of six digits (or other words) are presented on each trial, three to each ear, this task involves a substantial immediate memory load. Also, the order in which the items in each ear are encoded and retrieved from memory is a significant factor with which to reckon. Differences in ear asymmetry between groups of psychiatric patients and normal controls on this free-recall task are, therefore, difficult to interpret because differences in perceptual asymmetry can be confounded by those of memory loss and report order.

Lerner, Nachshon, and Carmon (1977) were the first to report evidence of altered dichotic laterality in psychiatric patients. They tested right handed schizophrenic patients and normal controls on two dichotic digit tasks, in which either three-digit or four-digit pairs were presented on each trial. Half of the schizophrenic patients were diagnosed as having paranoid disorders and half nonparanoid disorders based on the criteria of Tsuang and Winokur (1974). All patients were hospitalized and receiving antipsychotic medications. Overall accuracy of dichotic recall was poorer in schizophrenic patients compared to normal controls, but did not differ among the paranoid and nonparanoid subgroups. The paranoid group showed considerably greater right ear advantage than did normal controls, whereas the nonparanoid group had an intermediate ear asymmetry. They attributed the marked right ear advantage in paranoid schizophrenic patients to the tendency to report all digits for the right ear before reporting digits for the other ear, which they found to be particularly evident in the paranoid group. Thus, greater decay of memory for digits in the second reported ear (i.e., the left ear) could explain

the larger right ear advantage in this group when compared to the nonparanoid or normal groups. More recently, Nachshon (1980) reinterpreted the larger right ear advantage as being in line with the hypothesis of left hemisphere overactivation in schizophrenia (Gur 1978).

Lishman et al. (1978) found abnormally large right ear advantages not only for a group of schizophrenic patients but also for a group of patients with affective psychoses. They reported findings for psychotic patients and normal controls, all strongly right handed, who were tested on a dichotic word recall task. Of 15 patients who had schizophrenic psychoses, 7 were diagnosed as having paranoid disorders. Of 13 patients who had affective psychoses, 10 had a history of manic features. Lishman et al. (1978) indicate that most patients at the time of testing were attending an outpatient clinic and their florid symptoms were under control. However, most schizophrenic patients still showed some emotional blunting or mild psychotic symptoms. Virtually all of the schizophrenic patients were being treated with antipsychotic drugs and most affective patients were being treated with lithium, antidepressant drugs, or both at the time of testing. The results showed that both the schizophrenic and affective groups had larger right ear advantage and overall poorer recall when compared to normal controls. There was, however, no difference between the two patient groups on either measure. Although Lishman et al. (1978) discussed possible interpretations of these findings in terms of altered hemispheric function in psychosis, they cautioned that the overall poorer performance in the psychotic patients and such cognitive factors as memory load, selective attention, or

response strategies could account for the findings.

Gruzelier and Hammond (1980) tested schizophrenic patients and normal controls (all but two patients were right handed) on a dichotic recall task which differed in two respects from that used in the above studies. First, subjects were tested both in the usual free-recall condition and a directed-report condition in which they were signaled to report the digits in one ear before the other ear. The latter condition has the advantage of controlling for attentional and report order biases. Second, the digits in the two ears were either of equal intensity or 20 dB more intense in one ear. Gruzelier and Hammond (1980) indicated that the diagnosis of the schizophrenic patients was confirmed with the aid of the Present State Examination (Wing, Cooper, and Sartorius 1974) and 11 of the patients had paranoid disorders. The patients were tested during three periods in which they were given an antipsychotic drug, placebo, and, again, an antipsychotic drug. When they contrasted the performance of the schizophrenic patients and normal controls, no difference was found in either overall recall or right ear advantage between these groups. The same finding held when the data for the free-recall condition were analyzed separately from those for the directed-recall condition. There was also no difference in overall recall or right ear advantage in the schizophrenic patients when on and off antipsychotic drugs. Most importantly, when Gruzelier and Hammond (1980) subclassified the schizophrenic patients into paranoid and nonparanoid groups, they found significant differences across these subgroups. The paranoid patients gave evidence of a stronger right ear preference than nonparanoid patients.

The favoring of the right ear in paranoid patients was so great that they failed to show the normal left ear advantage when the digits were 20 dB more intense in the left ear. Also, the paranoid patients showed less switching across ears when reporting items than did the nonparanoid patients, an effect that is in accord with the finding of a greater right ear bias in report order among paranoid patients (Lerner, Nachshon, and Carmon 1977). When the paranoid patients were further subdivided into low and high arousal groups (on the basis of the presence of skin conductance orienting responses), only the high arousal patients showed the greater than normal right ear advantages reported previously for paranoid schizophrenic patients. They concluded that a high level of arousal in paranoid patients contributed to the heightened right ear recall for dichotic digits.

Goode, Manning, and Middleton (1981) measured dichotic word recall in a group of hospitalized patients who met Research Diagnostic Criteria (Feighner et al. 1972) for either schizoaffective disorder or schizophrenia. The patients were tested while unmedicated (minimum of 5 days) and again 1 month after drug treatment. The results showed no difference between the right ear advantage for the patient group and normal controls. This was the case both before and after drug treatment. Also, there were no significant relations between ear asymmetry scores of unmedicated patients and ratings of their symptomatology on the Brief Psychiatric Rating Scale (Overall and Gorham 1962).

Johnson and Crockett (1982) tested right handed patients who met *DSM-III* (American Psychiatric Association 1980) criteria for schizophrenia. The schizophrenic patients

showed no ear asymmetry, a finding which contrasts with the right ear advantage of schizophrenic groups in the four previous dichotic recall studies. A group of unipolar depressed patients, who met *DSM-III* criteria for major depressive disorder, also failed to show a right ear advantage. The absence of a right ear advantage for dichotic recall in unipolar depressed patients agrees with the findings of a recent unpublished study that likewise tested depressed patients ($n = 13$) who met *DSM-III* criteria for major depressive disorder (Fennell, Moskovitz, and Backus 1982).

Johnson and Crockett (1982) also found evidence that the lack of ear asymmetry in the depressive and schizophrenic groups was linked to their clinical state at the time of testing. Thus, while neither group showed an ear asymmetry upon admission to the hospital, both groups had a normal right ear advantage after clinical remission (at discharge). Johnson and Crockett (1982) observed that the return to normal asymmetry following clinical remission was not merely due to a generalized improvement in attention. At discharge the depressed and schizophrenic groups showed an improvement in recall of words presented to the right ear, while recall of words presented to the left ear was unchanged.

Staggered Spondaic Word Test. The Staggered Spondaic Word Test is a dichotic word perception task that involves substantially less memory load than the dichotic recall task. The test consists of presenting two spondaic words (e.g., upstairs and downtown), one to each ear. The words are staggered in time so that the last syllable of the first spondee (stairs) occurs simultaneously, and

thereby competes with, the first syllable of the second spondee (down). The listener's task is simply to repeat the words. The difference in accuracy for identifying competing syllables in the right and left ear then provides a measure of dichotic ear asymmetry. The simplicity of the task is seen in the fact that normal subjects show few errors in either ear. The Staggered Spondaic Word Test does not give a measure of language dominance in normal subjects because of the scarcity of errors in either ear. Rather, the test was designed as an aid for evaluating central auditory nervous system dysfunction (e.g., Katz 1977). Temporal lobe lesions that involve auditory receptive damage consistently produce poor performance for competing syllables in the ear contralateral to the lesion.

Yozawitz et al. (1979) tested right handed schizophrenic patients, affective psychotic patients, and normal controls on the Staggered Spondaic Word Test. All patients were hospitalized and were receiving antipsychotic medications at the time of testing. They exhibited frank psychotic symptoms (e.g., delusions, flat affect, hallucinations) and many of the affective patients also exhibited manic or hypomanic features during the study. Two brain damaged patients with right temporal lesions were also tested, as a partial check on whether the tasks used in this study would show the expected laterality effects for unilateral lesions. While normal controls showed few errors in either ear and little or no ear asymmetry on the Staggered Spondaic Word Test, the right temporal lesioned patients displayed the left ear suppression and marked right ear advantage that are typical of the performance found for unilaterally lesioned individuals. The affective psychotic group also showed an abnormal right ear advan-

tage, while the schizophrenic group did not. Yozawitz et al. (1979) observed that the affective psychotic patients, as well as the right temporal lesioned patients, performed more poorly than normal controls only in the left ear. The unimpaired right ear performance makes it difficult to attribute the abnormal right ear advantage in these patients to a generalized performance decrement.

The findings of Yozawitz et al. (1979) for affective psychotic patients are in accord with those of Lishman et al. (1978) for their dichotic recall task and indicate that the factor of memory load is not critical in accounting for the lateralized deficit in these patients. The affective psychotic patients in both studies, many of whom had bipolar disorders with manic features, displayed abnormally large right ear advantages. Although this is in line with the hypothesis of right hemispheric dysfunction in affective disorders (e.g., Gruzeller and Venables 1974; Flor-Henry 1976), it does not lend strong support for the hypothesis because of the other possible alternative interpretations of the increased right ear advantage—for example, left hemisphere overactivation, interhemispheric communication deficit, or overall performance level.

The findings of Yozawitz et al. (1979) for schizophrenic patients agree with the results of two unpublished studies that also used the Staggered Spondaic Word Test (Polidoro 1970; Flor-Henry et al. 1980). In all three studies, schizophrenic patients performed more poorly than normal controls on competing syllables. There was, however, no evidence of a lateralized deficit in central auditory nervous system function for the groups of schizophrenic patients in these studies.

One final word of caution concern-

ing the Staggered Spondaic Word Test. The test is so easy that not only normal subjects but also many depressed and hypomanic patients who are not psychotic show near perfect accuracy in each ear (e.g., Flor-Henry et al. 1980). This will, of course, limit the laterality effects that can be observed in these subjects and render the results worthless for observing subtle differences in lateralized hemispheric function.

Dichotic Nonsense Syllable Tasks. Dichotic listening studies have made extensive use of nonsense syllables, most frequently consonant-vowel syllables (ba, da, ga, pa, ta, and ka), recorded in either natural speech (e.g., Studdert-Kennedy and Shankweiler 1970; Berlin et al. 1973) or synthetic speech (e.g., Shankweiler and Studdert-Kennedy 1975; Repp 1978). Since the onsets of the dichotic consonant-vowel syllables in the two ears can be aligned within about 1 millisecond, the likelihood increases that the syllables will fuse to form a single percept. The tendency to fuse depends not only on the precision of alignment but also on the spectral similarity of the syllables. While tasks using natural consonant-vowel stimuli have an advantage of good intelligibility, only some of the dichotic pairs will fuse to form a single percept. The use of synthetic speech permits greater control over spectral similarity, and it is thereby possible to construct tasks using synthetic consonant-vowel syllables in which dichotic pairs are "perfectly fused." An important methodological advantage of using perfectly fused syllables is that selective attention to one ear has little or no effect on performance (Repp 1977), whereas this is certainly not the case for unfused stimuli.

Synthetic nonsense syllables that fuse to form a single percept also

provide a way of minimizing the influence of memory load and response strategy in dichotic listening studies with psychiatric patients. This led Colbourn and Lishman (1979) to use a synthetic nonsense syllable task in the followup to their initial study. The task consisted of presenting a different consonant-vowel syllable to the two ears and the subject was asked to mark down two responses. The right handed subjects consisted of patients who had schizophrenic psychoses, patients who had affective psychoses, nonpsychotic patients who had neurotic or personality disorders, and normal controls. The psychiatric diagnoses were made with the aid of the Present State Examination (Wing, Cooper, and Sartorius 1974). A majority of the patients were receiving inpatient care, most were receiving regular medications, and the florid symptoms of the psychotic patients were under control at the time of testing. All of the groups showed the expected right ear advantage for dichotic consonant-vowels except for the schizophrenic patients, who showed essentially no ear asymmetry. This lack of ear asymmetry was a result of the poorer right ear performance in schizophrenic patients compared to normal controls, while there were no group differences in accuracy for the left ear. Colbourn and Lishman (1979) suggest that their findings for schizophrenic patients are consistent with a deficit in left hemisphere cognitive function. They refer to a similar study in the visual modality by Gur (1978), in which consonant-vowel-consonant syllables were presented to the left or right visual field. The schizophrenic patients in this study showed poorer right visual field performance compared to normal controls, while there was no difference between groups for the left visual field. Gur's (1978) find-

ings give even stronger evidence of left hemisphere dysfunction since the schizophrenic group displayed a reversal of the normal direction of asymmetry, i.e., the schizophrenic group had a *left* visual field advantage.

Although Colbourn and Lishman (1979) found that their schizophrenic group showed no ear asymmetry, the individual asymmetry scores revealed a bimodal distribution not evident in other groups. About as many schizophrenic patients displayed a left ear advantage as a right ear advantage. Thus, while some schizophrenic patients did show an ear asymmetry consistent with left hemispheric disturbance, others did not. What was not revealed in this study is whether individual differences in direction of ear asymmetry among schizophrenic patients were related to diagnostic subtypes or other clinical features, e.g., symptomatology or response to treatment.

Two studies provide evidence that the magnitude of ear asymmetry on dichotic nonsense syllable tasks is related to a patient's clinical state at the time of testing. Wexler and Heninger (1979) tested right handed psychotic patients repeatedly over the course of their hospitalization and related changes in ear asymmetry to changes in symptom ratings. The dichotic stimuli consisted of "highly fused" vowel-consonant-vowel syllables, and the subjects were required to report only a single syllable on each trial. The patients met Research Diagnostic Criteria (Spitzer, Endicott, and Robins 1978) for schizophrenia, schizoaffective disorder, or primary major depressive disorder. They were tested once a week during their hospital stay. During the first week (usually before drug treatment) there was no difference in ear asymmetry between the schizophrenic, schizoaffective,

and depressive groups or between any of these groups and normal controls. The schizophrenic group did, however, make more errors than did normal controls. The chief finding of this study was an association between increased ear asymmetry and symptom remission. During the week when the patients were rated as being most ill (high ratings of global illness, depressed mood, and thought disorder), they had lower ear asymmetry scores compared to the week when they were least ill. Since the patients also made significantly more errors when they were most ill, an important question is whether the reduced ear asymmetry could merely be due to a generalized performance decrement. Wexler and Heninger (1979) argue that the changes in ear asymmetry were independent of performance level and cite as evidence the fact that the number of errors when the patients had the lowest asymmetry did not differ from the number of errors when they had the highest asymmetry.

Moscovitch, Strauss, and Olds (1981) also found evidence that an improvement in clinical state is paralleled by an increase in ear asymmetry. They used a dichotic consonant-vowel task in which the subjects were required to attend to and report the syllable in one ear on half of the trials and the opposite ear on the other half of the trials. Right handed unipolar depressed patients, who had previously failed to respond to antidepressant medication, were tested before unilateral right electroconvulsive therapy (ECT), 4 hours after their second treatment, and again 3-4 months after treatment. Before treatment, when the patients were severely depressed, they failed to show any ear asymmetry. However, on the two occasions when they were

tested after treatment, they had the normal pattern of right ear advantage. It is important to note that there was no change in overall accuracy after treatment, but, rather, the improvement in right ear performance was accompanied by a decrement in left ear performance.

Summary of Findings for Verbal Dichotic Tasks. The findings of the studies outlined in table 1 indicate that groups of right handed schizophrenic patients generally display a right ear advantage on verbal dichotic tasks. Only two studies failed to find a right ear advantage in schizophrenic patients and no study found a left ear advantage parallel to the left visual field advantage in schizophrenic patients for tachistoscopically presented verbal material (Gur 1978). This pattern is clearly not what would be expected if schizophrenia involved a left-lateralized lesion that impinged on the primary auditory receptive region in the temporal lobe. Two studies found the right ear advantage in schizophrenic patients to be even larger than in normal controls, while a third study found this to be the case for paranoid but not nonparanoid patients. It would appear that heightened right ear advantage is also not characteristic of schizophrenia in general but, perhaps, of only a subgroup of patients who are more likely to be diagnosed as paranoid than nonparanoid (Lerner, Nachshon, and Carmon 1977) and who display a high level of electrodermal arousal (Gruzeliel and Hammond 1980).

Two of the studies outlined in table 1, as well as one unpublished report (Fennell, Moskovitz, and Backus 1982), failed to find a right ear advantage in patients with affective disorders. In each of these studies, the patients were diagnosed as having

unipolar depressive disorders. In contrast, two studies found an abnormally large right ear advantage for groups of affective psychotic patients who had primarily bipolar disorders with manic features. Further evidence is reviewed below that indicates the importance of making the unipolar versus bipolar distinction in dichotic listening studies.

Several studies observed within subject changes in ear asymmetry for patients in different clinical states. Greater severity of schizophrenic or depressive symptomatology tends to be associated with reduced right ear advantage for verbal dichotic material. In both schizophrenic and depressed patients, clinical recovery was accompanied by a normalization of the right ear advantage.

Nonverbal Dichotic Tasks

The nonverbal dichotic tasks used in studies of cerebral laterality and psychopathology (see table 2) have some distinct advantages. Many of the methodological problems encountered in verbal dichotic tasks, such as memory load, response strategy, stimulus intelligibility, and stimulus dominance (Repp 1977), can be reduced or avoided by using certain nonverbal dichotic tasks that require a detection or discrimination response. Moreover, the use of both a nonverbal task and a verbal task provides converging lines of evidence for assessing right and left hemisphere function. A number of nonverbal dichotic tasks have been introduced to provide a measure of right

hemisphere auditory function. Although dichotic tasks using musical stimuli (e.g., melodies) have generally yielded a left ear (right hemisphere) advantage for groups of normal right handed subjects (Kimura 1964), this ear asymmetry appears to be weaker or less reliable than the right ear advantage for verbal dichotic tasks (Blumstein, Goodglass, and Tartter 1975). Dichotic pitch discrimination tasks (Colbourn and Lishman 1979; Sidtis 1981), which require the recognition of tone contours or complex tones, yield a left ear advantage that is about as large as the right ear advantage for dichotic nonsense syllable tasks. Another development has been the use of a task that involves simply the detection of dichotic click stimuli (Yozawitz et al. 1979; Bruder

Table 2. Dichotic listening in schizophrenia and affective disorders: Nonverbal tasks

Study	Task	Subjects	Findings
Colbourn & Lishman (1979)	Dichotic pitch discrimination (tone contours)	16 Schizophrenics 10 Affective psychotics 13 Nonpsychotic controls 19 Normals	Left ear advantage same for patient and normal groups
Johnson & Crockett (1982)	Dichotic musical chords	16 Schizophrenics 16 Unipolar depressives 16 Normals	Unipolars failed to show a left ear advantage, whereas schizophrenics showed a normal asymmetry
Yozawitz et al. (1979)	Dichotic click detection	10 Schizophrenics 9 Affective psychotics (most had manic features) 10 Normals	Affective psychotics showed a reversal of normal advantage for left ear lead condition, whereas schizophrenics showed a normal asymmetry
Bruder et al. (1981)	Dichotic click detection	14 Bipolar depressives 19 Unipolar depressives 15 Normals	Bipolars showed a reversal of normal advantage for left ear lead condition, whereas unipolars showed no asymmetry
Altman, Balonov, & Deglin (1979)	Dichotic click localization	6 Depressives or schizophrenics	Localization was disrupted by right ECT but not left ECT
Sackeim et al. (In press)	Dichotic click localization	1 Bipolar patient in depressive and hypomanic phases	Bias to localize clicks toward right hemisphere during depression and left hemisphere during hypomania

et al. 1981). This task has the advantage of circumventing the problem of overall poor performance in psychiatric patients. Researchers have also begun to use a dichotic click localization task to provide a measure of auditory spatial function, which is thought to be lateralized to the right hemisphere (Altman, Balonov, and Deglin 1979; Sackeim et al., in press).

Dichotic Pitch Discrimination. Colbourn and Lishman (1979) used a task that required subjects to discriminate brief pitch changes (tone contours). A different tone contour was presented simultaneously to the two ears, and the subject marked down two responses. The dichotic pitch discrimination task was in other respects parallel to the dichotic consonant-vowel task used in their study. The groups of schizophrenic patients, affective psychotic patients, nonpsychotic patients, and normal controls all showed the expected left ear (right hemisphere) advantage. There were no differences in pitch discrimination performance between groups in either ear, which contrasts with the poor right ear performance of the schizophrenic patients on the dichotic consonant-vowel task. Colbourn and Lishman (1979) concluded that the schizophrenics' performance on the verbal and nonverbal dichotic tasks was consistent with a deficit of left hemisphere cognitive function.

Dichotic Musical Chords. Johnson and Crockett (1982) also tested groups of schizophrenic patients, unipolar depressive patients, and normal controls on both a verbal and a nonverbal dichotic task. The nonverbal task consisted of presenting a different musical chord simultaneously to each ear; the subject then picked out the two chords from a series of four

binaurally presented chords. The schizophrenic patients had the same left ear advantage for musical chords as found for normal controls, whereas they failed to show the normal right ear advantage on the dichotic word recall task. This finding is in good agreement with the findings of Colbourn and Lishman (1979) for schizophrenic patients, which were also suggestive of a disturbance in left hemisphere but not right hemisphere function. In contrast, Johnson and Crockett (1982) did not find a left ear advantage for chords in their group of depressed patients. They found a lack of ear asymmetry on both verbal and nonverbal tasks in the depressed patients and a return to the normal pattern of ear asymmetry following clinical remission. This suggests that the relation between increased ear asymmetry and recovery from depression is not specific to verbal dichotic tasks but holds for nonverbal dichotic tasks as well. The schizophrenic patients also showed a shift in ear asymmetry for dichotic chords following clinical remission, but in the opposite direction of that seen for depressed patients. Surprisingly, the ear asymmetry for schizophrenic patients changed from a normal left ear advantage at hospital admission to an abnormal right ear advantage after clinical remission. Johnson and Crockett (1982) suggest that schizophrenic patients, in remission, may have an atypical pattern of hemispheric dominance in which the left hemisphere processes both verbal and nonverbal information.

Dichotic Click Detection. Whenever the ear asymmetry scores of groups differing in performance level are compared, one is faced with considerable ambiguity in interpreting the findings because of the correlation of ear asymmetry scores and total accu-

racy (Repp 1977). One dichotic task on which psychiatric patient and normal control groups do not differ in performance level is referred to as dichotic click detection.

Yozawitz et al. (1979) used the dichotic click detection task in their study of perceptual asymmetry in psychotic patients. The dichotic click paradigm consists of presenting a click to one ear followed, after a brief delay (60 msec), by a click to the other ear. The threshold intensity needed by subjects to detect the dichotic click stimulus was measured using a three-interval forced-choice technique. Specifically, the dichotic click stimulus was presented during one of three observation intervals and the subject's task was to indicate in which interval the stimulus occurred by pressing one of three response buttons. The threshold intensity was measured for a dichotic click stimulus in which the left ear click preceded the right ear click, and also, for a dichotic click stimulus with the opposite order of presentation.

The subjects were the same psychotic patients and normal controls who were tested on the Staggered Spondaic Word Test. Yozawitz et al. (1979) found that normal controls required less intensity to detect dichotic click stimuli when the left ear click preceded the right ear click compared to the opposite order of clicks. While the schizophrenic patients showed the same advantage for the left ear leading condition as found for normal controls, the affective psychotic patients showed the reverse ear asymmetry. The advantage for the right ear leading condition in affective psychotic patients was similar to that seen for two brain damaged patients with right temporal lesions. Thus, the same group of affective psychotic patients who had an abnormally large right ear advantage on the

Staggered Spondaic Word Test also showed an advantage for detecting the right ear leading condition. Yozawitz et al. (1979) concluded, that the abnormal pattern of ear asymmetry displayed by affective psychotic patients on both verbal and nonverbal tasks was consistent with the hypothesis of right dysfunction in affective disorders. One issue that was left unresolved in this study was the diagnostic subtype of the affective psychotic patients who showed the lateralized deficit. Since many of them exhibited manic or hypomanic features during their current episode, Yozawitz et al. (1979) suspected that these patients had primarily bipolar affective disorders.

Bruder et al. (1981) contrasted the dichotic click detection performance of bipolar versus unipolar depressed patients who met Research Diagnostic Criteria (Spitzer, Endicott, and Robins 1978). Although the severity of depressive symptoms varied widely from patient to patient, the average Hamilton Depression Scale scores did not differ for the bipolar and unipolar groups. The patients in the two groups were unmedicated for about an equal period (in most cases 7-14 days) before testing. All of the subjects were right handed. In accordance with the findings of Yozawitz et al. (1979), normal controls had a lower threshold intensity when the left ear click preceded the right ear click compared with the opposite order of clicks. Also, bipolar depressed patients showed the same reversal of ear asymmetry, i.e., an advantage for the right ear leading condition, as found by Yozawitz et al. (1979). In contrast, the unipolar depressed group showed essentially no ear asymmetry. There were no differences in monaural thresholds across ears or groups that could account for the differences in ear asymmetry of

dichotic click thresholds among the bipolar, unipolar, and normal groups.

Bruder et al. (1981) used ratings on the Schedule for Affective Disorders and Schizophrenia (Endicott and Spitzer 1978) to investigate the relation between individual differences in severity of symptoms among depressed patients and the magnitude of ear asymmetry on the dichotic click detection task. In both bipolar and unipolar depressed patients, higher ratings on scales of "Depressive Mood and Ideation" were associated with less ear asymmetry. There was also a particularly strong negative correlation ($r = -.80$, $p < .01$) between ratings of "Endogenous Features" and the magnitude of ear asymmetry among bipolar depressed patients. These findings agree with the intraindividual associations demonstrated between patients' clinical state at the time of testing and the magnitude of ear asymmetry on both verbal and nonverbal dichotic tasks (Wexler and Heninger 1979; Moscovitch, Strauss, and Olds 1981; Johnson and Crockett 1982).

Dichotic Click Localization. The dichotic click paradigm has also been used to measure sound source localization. When the interval separating a suprathreshold click in the two ears is in the region of 0.1 msec to 0.5 msec, the subject perceives a single "fused click" localized in the direction of the ear that receives the lead click. Normal subjects have little difficulty in localizing the apparent direction of the "fused click." Disturbance of the ability to localize sounds in either dichotic or free-field tasks has been associated with unilateral right brain damage (e.g., Shankweiler 1961; Ruff, Hersh, and Pribram 1981).

Altman, Balonov, and Deglin

(1979) measured sound source localization of dichotic click stimuli in a mixed group of right-handed psychiatric patients suffering from depression or schizophrenia. Measures were taken before and immediately after ECT to the right or left temporal region, which presumably resulted in a temporary functional disorder of the right or left hemisphere. The dichotic click stimuli had interaural delays of 0, 0.2, 0.4, and 0.8 msec, and the patients were instructed to point to where they heard the sound on the surface of the head. Localization of the dichotic clicks was disrupted by right-sided but not by left-sided ECT. Following right-sided ECT, the perceived location of all dichotic stimuli was displaced toward the right ear and no stimuli were located near the left ear. The disturbance of sound source localization after right-sided shock was similar in nature to the left-hemispatial neglect observed in patients with right brain damage, particularly in the temporal and parietal areas (e.g., Hecaen and Albert 1978; Heilman 1979).

Sackeim et al. (in press) used a dichotic click localization task in combination with a dichotic consonant-vowel task and measures of conjugate lateral eye movements. The dichotic click stimuli were separated by interaural delays of from 0.01 msec to 0.4 msec and the subjects identified the location of the sound by using a 6-point rating scale. Data were reported for a right-handed patient who met Research Diagnostic Criteria (Spitzer, Endicott, and Robins 1978) for bipolar disorder with hypomania and who was unmedicated during the tests. While no general inference can be drawn from a single case, the significance of this report lies in its suggestion of the importance of comparing dichotic listening in depressive and hypomanic phases

of bipolar illness. When depressed, the patient showed no ear asymmetry on a standard dichotic consonant-vowel task (Berlin et al. 1973), which is in line with similar findings for depressed patients (Moscovitch, Strauss, and Olds 1981). What was surprising, however, was the finding of a marked bias to localize dichotic clicks toward the right side of space and a strong tendency for right conjugate lateral eye movements when the patient was depressed. During the hypomanic phase, the direction of the bias for localizing sounds and the conjugate lateral eye movements were reversed in favor of the left side of space. When hypomanic, the patient also showed a left ear advantage on the dichotic consonant-vowel task. These data are opposite in direction to what would be expected if depression were associated with relative right hemisphere hyperactivation (e.g., Myslobodsky and Horesh 1978). Sackeim et al. (in press) suggested that this bipolar depressed patient has reversed direction of affective lateralization, in which depression is accompanied by left hemisphere hyperactivation and hypomania is accompanied by right hemisphere hyperactivation. In addition to calling attention to the issue of individual differences in the direction of affective lateralization among depressed patients, this case report suggests the need for further study of intraindividual changes in perceptual asymmetry that accompany the different phases of bipolar affective illness.

Summary of Findings for Nonverbal Dichotic Tasks. As can be seen in table 2, all three studies that tested groups of schizophrenic patients on nonverbal dichotic tasks found a perfectly normal left ear advantage for schizophrenic patients. This contrasts

sharply with what has generally been found for patients with affective disorders. Three of the four studies that tested groups of patients with unipolar or bipolar affective disorders failed to find a left ear advantage for these groups. There was also evidence of a difference in laterality patterns for unipolar and bipolar affective disorders. Unipolar patients in two studies showed essentially no ear asymmetry, while bipolar patients in two studies showed a complete reversal of the normal direction of asymmetry.

Two studies found a relationship between the clinical state of depressed patients and the magnitude of ear asymmetry for nonverbal dichotic tasks. Individual differences in severity of depressive and endogenous symptoms were associated with differences among patients in the magnitude of ear asymmetry. Patients with higher ratings on depression scales had smaller ear asymmetry scores. Also, a group of unipolar depressed patients, who showed essentially no ear asymmetry when depressed, had a normal left ear advantage following clinical recovery.

Conclusion

Studies of dichotic listening in psychiatric patients have provided evidence suggestive of alterations of cerebral laterality in schizophrenic and affective disorders. Although the findings of some studies have been interpreted as favoring current hypotheses of left hemispheric involvement in schizophrenia and right hemispheric involvement in affective disorders, not all studies have found evidence supportive of these hypotheses. There are, however, some consistent trends across studies which

indicate that ear asymmetry on verbal and nonverbal tasks is dependent on both the patient's clinical state at the time of testing and the patient's specific diagnostic characteristics.

Clinical State. A relationship between depression and magnitude of ear asymmetry has now been reported in several studies. Increasing severity of depressive and endogenous features is associated with less ear asymmetry (Wexler and Heninger 1979; Bruder et al. 1981), while clinical remission of depression is accompanied by a return to the normal level of ear asymmetry (Moscovitch, Strauss, and Olds 1981; Johnson and Crockett 1982). Since this relationship seems to hold equally for both verbal and nonverbal dichotic tasks, it may be independent of the direction of ear asymmetry.

There are a number of possible explanations of the association between increased severity of depression and reduced magnitude of dichotic ear asymmetry. One possibility would be that the reduced ear asymmetry is related to a generalized decrement in performance, which might be expected to occur when patients are more severely ill. The data do not support this explanation, since in some studies the pretreatment versus posttreatment changes in ear asymmetry were not accompanied by a change in overall accuracy (Moscovitch, Strauss, and Olds 1981; Johnson and Crockett 1982). An explanation that could account for the relationship between depression and degree of ear asymmetry, and its independence from the direction of asymmetry, was advanced by Wexler and Heninger (1979). If interhemispheric inhibition is responsible for maintaining a normal degree of ear asymmetry, a breakdown of this in-

hibition during depression could result in less asymmetry. Of course, this still leaves unanswered questions concerning the nature and locus of the mechanism that is hypothesized to maintain laterality. An alternative explanation offered by Moscovitch, Strauss, and Olds (1981) would account for the lack of a right ear (left hemisphere) advantage for depressed patients on a verbal dichotic task in terms of right hemisphere overactivation. This interpretation would, however, have difficulty in explaining why the lack of ear asymmetry in depression appears to hold equally for nonverbal tasks for which the right hemisphere is presumably dominant. One way out of this bind would be to hypothesize that elements of both right hemisphere overactivation and right hemisphere dysfunction combine to reduce ear asymmetry on both verbal and nonverbal tasks. For instance, Tucker et al. (1981) have suggested that right frontal activity associated with depressive affect could also act to inhibit the right hemisphere's processing capacity. Another possible explanation is that heightened right frontal activity during severe depression may result in bilateral activation of auditory centers in the temporal lobe and thereby reduce ear asymmetry for both verbal and nonverbal dichotic tasks. This explanation is based upon a model of cerebral activation in which a cortico-limbic reticular loop involving right frontal and parietal areas is hypothesized to play a dominant role in the activation of not only the right hemisphere but also the left hemisphere via interhemispheric pathways (Heilman and Valenstine 1979). Support for the role of the right hemisphere in mediating bilateral cerebral activation has been provided by studies using behavioral measures (Heilman and Van Den Abell 1979; Bow-

ers and Heilman 1980) and a more direct measure of hemispheric activation, regional cerebral blood flow (Prohovnik et al. 1980). The latter measure and other new techniques for mapping cerebral activity should prove particularly useful in evaluating the explanations advanced to account for the relationship between severity of depression and magnitude of dichotic ear asymmetry.

The increase in right ear advantage for verbal dichotic tasks following clinical improvement is not specific to depressive illness but occurs in schizophrenia as well (Johnson and Crockett 1982). In psychotic patients, greater right ear advantage was associated not only with lower ratings of depressed mood but also lower ratings of first rank symptoms of schizophrenia, i.e., thought disorder, paranoid behavior, and hallucinations (Wexler and Heninger 1979). Wexler and Heninger (1979) have concluded that the breakdown of processes involved in maintaining laterality is not specific to one diagnostic group but is associated with psychotic symptomatology. However, the recent findings of Johnson and Crockett (1982) suggest that the relationship between magnitude of ear asymmetry and clinical state is different for depressed and schizophrenic groups in one important respect. While in depressed patients the relationship was the same for verbal and nonverbal dichotic tasks, this was not the case for schizophrenic patients. The schizophrenic group showed a normal left ear (right hemisphere) advantage on a nonverbal task, but following clinical remission shifted to an abnormal right ear (left hemisphere) advantage. These findings suggest the possibility that reduced ear asymmetry in schizophrenic patients on verbal tasks is associated with left hemisphere dys-

function, which is overcome by a marked increase in left hemisphere activation following clinical recovery. This would be consistent with the view that aspects of both left hemisphere dysfunction and overactivation are involved in schizophrenia (Gur 1978).

Diagnostic Characteristics. The first diagnostic issue that should be addressed is whether patients with schizophrenic and affective disorders differ in ear asymmetry. Comparison of ear asymmetry for schizophrenic and affective patients on verbal dichotic tasks has in most cases not revealed significant group differences. Three studies that used both verbal and nonverbal dichotic tasks have, however, found differences in the ear asymmetry of schizophrenic and affective patients (Colbourn and Lishman 1979; Yozawitz et al. 1979; Johnson and Crockett 1982). The groups of schizophrenic patients in all three studies showed the normal left ear (right hemisphere) advantage on nonverbal dichotic tasks. Generally, groups of patients with affective disorders have either shown no ear asymmetry or a complete reversal of the normal direction of asymmetry on the same nonverbal dichotic tasks (Yozawitz et al. 1979; Bruder et al. 1981; Johnson and Crockett 1982). Thus, the main evidence for differences in perceptual asymmetry between patients with schizophrenic and affective disorders has been for nonverbal dichotic tasks.

Part of the difficulty in demonstrating consistent differences in ear asymmetry for schizophrenic and affective disorders was no doubt due to the heterogeneity of patients within these diagnostic groups. A comparison of the dichotic listening findings for the schizophrenic groups in different studies reveals some marked

differences across studies (see table 1), which may in part stem from differences in the diagnostic characteristics of the patients in these studies. In general, the findings of studies that tested schizophrenic patients on verbal dichotic tasks do not indicate that schizophrenia is associated with a left-lateralized lesion in the central auditory nervous system. However, there is reason to believe that a subgroup of schizophrenic patients do display an absence of ear asymmetry or even a left ear advantage on verbal dichotic tasks, which would be consistent with left hemisphere dysfunction (Colbourn and Lishman 1979). What is not known is whether patients in this subgroup differ from other schizophrenic patients in their diagnostic subtypes or other clinical features—for example, symptomatology, family history of illness, or response to antipsychotic medications. Conversely, there may also be a subgroup of schizophrenic patients who display large right ear (left hemisphere) advantages on dichotic recall tasks. There is evidence to suggest that these patients are more likely to be diagnosed as paranoid than nonparanoid and tend to display a high level of arousal in their skin conductance orienting responses (Lerner, Nachshon, and Carmon 1977; Gruzelier and Hammond 1980). Magaro (1981) has suggested that the difference in information processing between paranoid and nonparanoid schizophrenia may stem from a difference in hemispheric functioning in these groups. Namely, he hypothesized that paranoids prefer left hemisphere processing, while nonparanoids prefer right hemisphere processing. Similarly, Gruzelier (1981) reviewed evidence for the existence of two syndromes of schizophrenia with distinctive laterality patterns on behavioral and psychophysiological

measures, and with clinical features that approximate the paranoid-nonparanoid distinction. More research along these lines is needed to define further the clinical and psychophysiological differences between schizophrenic patients with different laterality patterns.

Additional evidence for the influence of diagnostic characteristics on ear asymmetry is found in the dichotic listening data for patients with affective disorders. Two of the seven studies that have tested affective patients on verbal dichotic tasks have reported finding an abnormally large right ear advantage consistent with the hypothesis of right hemisphere dysfunction in affective disorders (Lishman et al. 1978; Yozawitz et al. 1979). These two studies had one thing in common. Their patients had primarily bipolar affective disorders in which current or past manic features were present. In contrast, three studies that identified their patients as having unipolar depressive disorders found no ear asymmetry for these groups (Moscovitch, Strauss, and Olds 1981; Fennell, Moskovitz, and Backus 1982; Johnson and Crockett 1982). One study that specifically contrasted the ear asymmetry of depressed patients with either bipolar disorders (history of mania or hypomania) or unipolar disorders found a similar group difference on a dichotic click detection task (Bruder et al. 1981). While the bipolar group showed an abnormal direction of ear asymmetry on this nonverbal dichotic task (i.e., an advantage for the right ear leading condition), the unipolar group had no ear asymmetry.

Patients with bipolar affective disorders that involve a manic or hypomanic component appear to be particularly likely to display an abnormally large right ear advantage on

verbal dichotic tasks and a reversal of the normal left ear advantage on a nonverbal dichotic task. Although both findings are consistent with a hypothesis of right hemisphere dysfunction, they could also be explained in terms of a hypothesis of left hemisphere overactivation. Sackeim et al. (1982) have reviewed studies linking right-brain damage, right hemispherectomy, or right-brain sedation with euphoric reactions or pathological laughter. They present evidence suggesting that this relationship is mediated via a release from inhibition of the contralateral left side of the brain. In a similar fashion, the possibility exists that the abnormal ear asymmetry patterns in bipolar affective disorders may stem not only from right hemisphere dysfunction but also from disinhibition or excitation in the left side of the brain.

Methodological Issues. There have been some marked differences across studies in the dichotic listening findings for schizophrenic patients. For instance, one group of researchers found an abnormally large right ear advantage in schizophrenic patients who were tested on a dichotic word recall task (Lishman et al. 1978) and yet, in a subsequent study, the same group found no right ear advantage in schizophrenic patients who were tested on a dichotic consonant-vowel recognition task (Colbourn and Lishman 1979). A likely explanation of this difference in findings would be the different dichotic tasks used in the two studies. Berlin and McNeil (1976) have reported that dichotic digit recall and dichotic consonant-vowel tasks can yield different results, which they attributed to differences between tasks with respect to recall, familiarity, and acoustic content.

Even studies that have used comparable dichotic listening tasks have in some cases yielded divergent results. In these instances, the complexity of doing research with clinical populations that are poorly defined becomes fully apparent. Since most studies have not used standardized Research Diagnostic Criteria (Spitzer, Endicott, and Robins 1978), comparisons across studies are often risky. Also, few studies have taken into account the heterogeneity of the major diagnostic categories. Nor have the specifics of the patients' clinical state (e.g., nature and severity of symptoms) at the time of testing been specified with sufficient detail in many studies. Thus, apparent differences in findings across studies are likely to be due not only to the specific dichotic task characteristics, but also to differences in the diagnostic subtype and clinical state of the patients in these studies.

Another methodological issue that makes it difficult to integrate findings in this area is that of medication control. The problem is twofold. First, relatively few studies have tested unmedicated patients who were given an initial drug washout period. In those studies that report dichotic listening findings for medicated patients, the question arises as to what effects, if any, can be attributed to the medication. Although there is some evidence that measures of hemispheric asymmetry may be altered by antipsychotic or antidepressant drugs (Serafetinides 1972; Perris 1974; Roemer et al. 1978), two studies did not find a significant change in dichotic ear asymmetry in schizophrenic patients when on and off antipsychotic drugs (Gruzelier and Hammond 1980; Goode, Manning, and Middleton 1981). Second, the long-term effects of chronic administration of antipsychotic or antide-

pressant medications on right and left brain function are unknown. A brief drug washout period would probably be of little value in overcoming effects that are due to years of drug treatment. Studies of unmedicated patients who have had little or no prior drug treatment and studies of children at risk for developing a schizophrenic or affective disorder are needed to help resolve this issue.

One methodological issue that has received considerable attention is the relation between behavioral asymmetry scores and performance level (Kuhn 1973; Marshall, Caplan, and Holmes 1975; Birkett 1977; Colbourn 1978). The use of simple difference scores (right ear - left ear scores) is problematical because such difference scores are correlated with performance levels (right ear + left ear scores). The negative correlations found between difference scores and total accuracy indicate that poorer performance was associated with greater asymmetry scores. A number of alternative indices of asymmetry can be derived, which are intended to minimize the contribution of performance level. Although some indices appear to be less influenced by performance level than other indices, the issue of what is the optimal index of asymmetry has not been resolved (Richardson 1976; Repp 1977; Colbourn 1978). One must necessarily use extreme caution in interpreting differences in dichotic ear asymmetry between patients and controls when these groups also differ in performance level. This problem is especially critical in research with schizophrenic patients, since these patients often perform more poorly than normal controls. The only sure solution is to demonstrate differences in ear asymmetry between groups of patients and normal controls in dichotic tasks on which the groups do not

differ in performance level. Several findings deserve note here. First, paranoid schizophrenic patients were found to have about twice as large a right ear advantage compared to nonparanoid schizophrenic patients, and yet, these groups did not differ in overall accuracy levels (Lerner, Nachshon, and Carmon 1977). Second, the differences in ear asymmetry among bipolar depressed patients, unipolar depressed patients, and normals on the dichotic click detection task cannot be attributed to performance level, since these groups did not differ in their overall threshold levels (Bruder et al. 1981). Third, pretreatment versus posttreatment changes in dichotic ear asymmetry for depressed and schizophrenic patients were found to occur in the absence of changes in overall accuracy (Wexler and Heninger 1979; Moscovitch, Strauss, and Olds 1981; Johnson and Crockett 1982).

Suggestions for Future Research. The major challenge that confronts studies of dichotic listening in psychiatric disorders is in the theoretical interpretation of findings. The problem is the multiple alternative interpretations that can often be given to the same results. Behavioral data alone do not allow the separation of some alternative hypotheses. For instance, the hypotheses of right hemisphere dysfunction and left hemisphere overactivation lead to the same laterality predictions on dichotic listening tasks. Also overactivation of one hemisphere (e.g., the left) could in turn stem from either contralateral disinhibition (e.g., due to right hemisphere deficit) or to ipsilateral release of subcortical processes (e.g., due to a left subcortical deficit). Greater attention to methodological details and use of multiple behavioral laterality measures, in conjunction

with psychobiological measures of hemispheric activity, would be of value in helping resolve these interpretive issues.

Some specific suggestions for future research in this area include:

- The use of both verbal and nonverbal dichotic tasks can provide converging operations for zeroing in on the correct interpretation. Since some dichotic tasks appear to be more reliable and valid than others, considerable attention should be given to selecting the best available dichotic tasks.
- It would also be preferable to include measures of cerebral laterality from another modality. This would indicate whether alterations of perceptual asymmetry are modality specific. For instance, one could use the verbal and nonverbal tachistoscopic tasks from Levy and Reid (1976), which would also allow one to compare findings with those of Gur (1978).
- It would be highly desirable to obtain not only behavioral laterality measures but also more direct measures of hemispheric activity by using the electroencephalogram, cortical evoked potentials, or regional cerebral blood flow measures.

On a more clinical level, progress in this area of research could also be aided in the following ways:

- Comparisons across studies would be facilitated by use of standardized interview schedules and research diagnostic criteria.
- There is a need to take into account the heterogeneity of schizophrenia and affective disorders. Future studies could compare cerebral laterality across subtypes of these disorders formed on the basis of diagnostic criteria, family his-

tory data, treatment response, or psychobiological measures.

- Specific symptom correlates of laterality patterns in patients should be studied using interview ratings of psychopathology.
- The relation between individual differences in cognitive and affective lateralization among patients with depressive disorders is an important issue for further research (Tucker 1981; Sackeim et al., in press).
- The study of intraindividual changes in laterality scores that accompany clinical remission following treatment provides needed information on the state versus trait issue. Also, the testing of patients in the different phases of bipolar affective illness will help resolve whether direction of laterality remains stable or shifts as a function of the valence of the clinical state, i.e., depression versus euphoria.

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