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8. The frequency to which a unit is most sensitive is called its best frequency.
9. Anuran species whose mating calls possess spectral peaks at high frequencies generally have poor auditory sensitivity. It has been suggested that this decrease in auditory sensitivity is due to a fall-off in the frequency response of the middle ear [J. J. Loftus-Hills and B. M. Johnstone, *J. Acoust. Soc. Am.* **47**, 1131 (1970)].
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12. Matched sensitivity of the high-frequency units to the spectral peak in the local male's mating call was also found in *Acris gryllus*. For example, high-frequency units in the medulla of *gryllus* from Georgia are all narrowly tuned around 3600 hz. The mating calls of male *gryllus* in Georgia have a *distinct* spectral peak near this same frequency. The sensitivities of the low-frequency units in *gryllus* are similar to those of *crepitans*, namely, distributed over the range of 200 to 1000 hz. This sensitivity is consistent with the hypothesis that the amphibian papilla provides a warning function for these tiny species. The mating cells of sympatric *crepitans* in Georgia have their spectral peaks centered around 4050 hz. Furthermore, the temporal patterns of clicks in the calls of the two species are very different, so that species-specific recognition involves both spectral and temporal signal characteristics (*2*). We did not explore the possibility of geographical variation in the auditory system of *A. gryllus*, although the characteristics of their calls also vary geographically (*2*).
13. The electrophysiological studies were conducted while R.R.C. and L.S.F. were members of the technical staff, Bell Telephone Laboratories, Murray Hill, New Jersey. Recording and analysis of mating calls were supported, in part, by grants GB-18836 to R.R.C. and GB--3167 to E.N. from the National Science Foundation.

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Flexible System for the Diagnosis of Schizophrenia: Report from the WHO International Pilot Study of Schizophrenia

Abstract. *Behavioral data on a large patient group were collected by investigators from nine countries in the International Pilot Study of Schizophrenia, sponsored by the World Health Organization. The data on half the group were analyzed to derive a system of 12 signs and symptoms for the identification of schizophrenia, as this disorder is diagnosed in many centers throughout the world. The findings were replicated with the other half of the patient group. The criteria constitute an operational method for identifying patients who would be commonly considered schizophrenic in many centers.*

Despite the efforts of many investigators over the years to develop methods for identifying patients with schizophrenia, widely accepted criteria for the differential diagnosis of this disorder have not been established. Regardless of their basic assumptions about schizophrenia, clinician and investigator alike require a system for classifying their patients in order to organize their concepts and to provide the basis for generalizations relevant to management, treatment, prognosis, or interpretation of biochemical, demographic, genetic, or other research data. Traditionally, signs and symptoms have been the key criteria in defining psychiatric classification (*1*).

In this report we present the results of an investigation to determine which clinical criteria are widely used as discriminating for schizophrenia. Such an investigation is possible with data collected by psychiatrists from nine countries in the International Pilot Study of Schizophrenia (IPSS) sponsored by the World Health Organization. This report, based on some of those data, defines an applicable, operational, and flexible system for identifying patients as schizophrenic. In a large cohort of patients, 12 signs and symptoms were found to be especially discriminating between schizophrenia and other psychiatric disorders. A diagnostic system based on these 12 variables was comparably effective in a second patient cohort.

The IPSS is a transcultural psychiatric investigation of 1202 patients in nine countries—Colombia, Czechoslovakia, Denmark, India, Nigeria, China, the Soviet Union, the United Kingdom, and the United States. It was designed as a pilot study to lay scientific groundwork for future international epidemiological studies of schizophrenia and other psychiatric disorders (*2*).

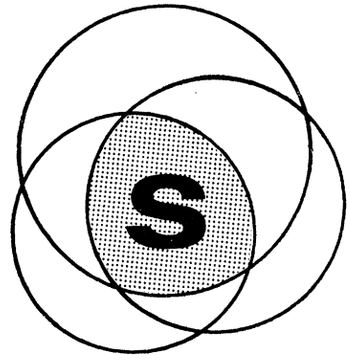

Fig. 1. Venn diagram.

The same inclusion and exclusion criteria were used for patients evaluated in all nine countries (*3*). The collaborating investigators in each nation used a standardized interview schedule, the Present State Examination (PSE), to elicit and record reliable sign and symptom data in patients recently hospitalized with evidence of psychosis (*2*). Standard psychiatric history and social description interviews were also used (*2*). After these interviews, psychiatrists in each country diagnosed their patients by using the categories of the International Classification of Disease (*4*).

Table 1 presents the diagnoses of the 1202 patients evaluated in the nine countries. Of these patients, 81 were dropped from this data analysis since their diagnoses could have been considered as belonging to either the schizophrenic or the nonschizophrenic group (see Table 1). The remaining 1121 patients were randomized by country to form cohorts A and B, each containing approximately 405 patients diagnosed schizophrenic and 155 patients diagnosed other than schizophrenic.

The PSE, used for rating patients' signs and symptoms, contains 360 items. For this study, the scoring of each item was either 0 (absent) or 1 (present). Missing information and ratings of questionably present were scored 0. The 360 individual items and the combinations of 55 items defining clinically relevant symptom groups were then arrayed as 415 overlapping variables. An analysis of variance was then carried out between patients diagnosed schizophrenic and nonschizophrenic in cohort A. The 150 strongest discriminators were inspected to eliminate the weaker of the overlapping variables. The surviving 69 variables are all statistically significant discriminators. They cover a broad range of psychopathology, including symptoms believed characteristic of schizophrenia by many psychodiagnostic schools.

The schizophrenic and nonschizophrenic patients in cohort A were then used as criteria for a stepwise discriminate function analysis (DFAn) to determine the interrelated discriminating power of the 69 variables. The 12 most discriminating symptoms were then made into a 12-point differential diagnostic system (*5*). The degree of discrimination between schizophrenia

Table 1. Diagnostic distribution of patient sample. The ICD numbers are code numbers in the *International Classification of Disease (4)*.

Clinical diagnosis	ICD number		Patients (No.)
	Psychosis		
Schizophrenia			
Simple	295.0		31
Hebephrenic	295.1		86
Catatonic	295.2		54
Paranoid	295.3		323
Acute	295.4		79
Latent	295.5		25
Residual	295.6		15
Schizo-affective	295.7		107
Other specified	295.8		44
Unspecified	295.9		47
		Total	811
Affective psychosis			
Agitated depression	296.0		5
Manic-depressive, depressed	296.2		73
Manic-depressive, manic	296.1		66
Other	296.3–296.9		20
		Total	164
Paranoid states*	297		29
Other psychoses			
Reactive depression	298.0		21
Others*	298.1–298.9 299, 294		52
		Total	73
		All psychosis	1077
	Neurosis and personality disorders		
Depressive neurosis	300.4		71
Others	300.0–300.3 300.5–301.9		54
		Total	125
		All patients	1202

* Excluded from the data analysis since they cannot be clearly assigned to the schizophrenic or nonschizophrenic group.

Table 2. Items from the Present State Examination (PSE) corresponding to the 12 signs or symptoms; *r*, reliability, intraclass correlation; (−) indicates that absence of the criterion favors a diagnosis of schizophrenia.

Sign or symptom	PSE observation or question	*r*
Restricted affect	Blank, expressionless face.	.62
	Very little or no emotion shown when delusion or normal material is discussed which would usually bring out emotion.	.63
Poor insight	Overall rating of insight.	.85
Thoughts aloud	Do you feel your thoughts are being broadcast, transmitted, so that everyone knows what you are thinking?	.95
	Do you ever seem to hear your thoughts spoken aloud? (Almost as if someone standing nearby could hear them?)	.74
Waking early (−)	Have you been waking earlier in the morning and remaining awake? (Rate positive if 1 to 3 hours earlier than usual.)	.83
Poor rapport	Did the interviewer find it possible to establish good rapport with patient during interview?	.86
	Other difficulties in rapport.	.75
Depressed facies (−)	Facial expression sad, depressed.	.73
Elation (−)	Elated, joyous mood.	.67
Widespread delusions	How widespread are patient's delusions? How many areas in patient's life are interpreted delusionally?	.74
Incoherent speech	Free and spontaneous flow of incoherent speech.	.74
Unreliable information	Was the information obtained in this interview credible or not?	.73
Bizarre delusions	Are the delusions comprehensible?	.69
Nihilistic delusions	Do you feel that your body is decaying, rotting?	None*
	Do you feel that some part of your body is missing, for example, head, brain, or arms?	.70
	Do you ever have the feeling that you do not exist at all, that you are dead, dissolved?	.71

* Insufficient variability to determine intraclass *r*.

and nonschizophrenia in cohort A was examined at various levels for inclusion and exclusion for the diagnosis of schizophrenia. An attempted replication was undertaken with cohort B, comprised of comparably evaluated patients who had not contributed to the derivation of this 12-point diagnostic system.

By the methods described above, 12 symptoms and signs were selected as being the most discriminating for patients diagnosed schizophrenic by the collaborating psychiatrists from nine countries. Table 2 shows the discriminating symptoms from the first 12 steps of the DFAn and lists the PSE items used to elicit the presence or absence of each of these symptoms. Reliability between different raters on these items is satisfactory and is detailed in the far right column of Table 2. Table 3 depicts the application of this 12-point system to the differential diagnosis of patients in cohort A and contains the results of the replication attempt with cohort B.

There are no definitive laboratory criteria or other objective validation criteria for identifying schizophrenia. There is, therefore, great need for defining diagnostic criteria that fit the core concept despite its diverse use. To be widely accepted for clinical and research purposes, discriminating variables that distinguish schizophrenic patients should be drawn from psychopathological features considered central across diagnostic schools. Criteria drawn from only one or two centers may be appropriate for those centers but not for others. Such results would continue the disparity among various schools and frustrate efforts to agree on the characteristic symptoms of schizophrenia.

An international study such as the IPSS has distinct methodological advantages in searching for characteristic signs and symptoms. The Venn diagram in Fig. 1 shows how criteria derived from the several centers in the IPSS can provide operational, widely acceptable diagnostic criteria. Each circle represents a diagnostic school's criteria for schizophrenia. The shaded area, *S*, represents the signs and symptoms considered important by most or all of the various diagnostic schools. For example, if loose associations are critical in one center while trivial in others, then this sign would have little discriminating power when the data are looked at collectively. On the other hand, if specific delusions are used as

discriminating by all investigators, then the power of that symptom will be confirmed. The basic assumption in this investigation is that a transcultural design will minimize criteria based on culturally determined phenomenological manifestations or idiosyncratic criteria of any particular diagnostic school. Rather, this study design should demonstrate the criteria used by a wide range of psychiatrists with various psychodiagnostic orientations. Furthermore, the broad range of behavioral data used in this analysis provides the basis for uncovering important signs and symptoms not previously considered highly discriminating. The 12 most discriminating symptoms (Table 2) describe nine criteria generally indicative of schizophrenia and three indicative of nonschizophrenia across nine diverse centers.

These 12 signs and symptoms can be elicited readily in the framework of a psychiatric interview. They have established reliability as used in the IPSS and this procedure can be readily taught. For these reasons, this system is generally applicable and reliable.

The 12 symptoms can be flexibly used as a system for identifying schizophrenia. Different levels of certainty can be chosen, and at each level the proportion of schizophrenic patients correctly included and the proportion of nonschizophrenic patients incorrectly included can be estimated. For example, as seen in Table 3, 80 percent of diagnosed schizophrenic patients are included if five or more points are required. With more demanding criteria, such as six or more symptoms, the proportion of diagnosed schizophrenics included is reduced, but an important reduction in false positive assignments occurs. More restrictive diagnoses at this level would be especially important in biological research on schizophrenia, where only a small number of subjects are tested. The estimate of incorrect inclusion is a critical and unique feature of this diagnostic scheme.

It was essential to test whether these findings could be replicated in a cohort other than that from which the criteria were derived. The results of the replication attempt with cohort B (Table 3) are not significantly different from those obtained from cohort A ($\chi^2 = 5.1$, d.f. $= 5$, $P > .40$). This replication demonstrates the reliability of the criteria.

This confirmation suggests that the 12-point system can provide a reliable operational method for identifying schizophrenic patients from groups of patients given the diagnoses affective psychosis, neurosis, and personality disorder. For clinical use this system is intended to enhance, not replace, clinical diagnosis, which should utilize all available information.

Table 3. Results of applying 12-symptom differential diagnostic system to cohort A patients and results of replication attempt with a different patient group (cohort B). Values are percentages of patients diagnosed schizophrenic or nonschizophrenic who are included when a particular number of symptoms are required. The number of patients in each category in cohort A and cohort B is given in parentheses.

Symptoms	Schizophrenic		Nonschizophrenic	
	A (407) (%)	B (404) (%)	A (154) (%)	B (156) (%)
4 or more	91	91	28	38
5 or more	80	81	13	22
6 or more	66	63	4	6
7 or more	44	39	1	1
8 or more	23	20	0	0

In addition to its clinical and educational uses, the system provides a tool for research groups interested in selecting schizophrenic patients for study. For example, if a biochemical abnormality were reported in ten patients diagnosed schizophrenic, who had at least seven of the discriminating symptoms, the reader could better judge the degree to which the patient sample is likely to be considered schizophrenic by psychiatrists generally. The use of standardized signs and symptoms also provides a definition of common descriptive features, permitting other groups to generate comparable patients for replication studies.

The systematic collection of extensive behavioral data on a large patient group by IPSS investigators has permitted the empirical derivation of discriminating signs and symptoms for the identification of schizophrenia, as this disorder is diagnosed in many centers throughout the world. Analysis of cohort A revealed 12 signs and symptoms that successfully discriminated diagnosed schizophrenics from other psychiatric patients. Replication was achieved in cohort B. The system thus defined has the advantage of being based on a small number of items that can be reliably ascertained by a clinician. It can be used at various levels of discrimination, depending on the purpose of the diagnosis. Thus, most diagnosed schizophrenic patients can be included, with a moderate number of presumed false-positives, if selection of a large cohort is important and erroneous inclusion of some nonschizophrenics will not cause major problems. Or, a group of schizophrenic patients can be selected more stringently, with virtually all nonschizophrenic patients excluded, when obtaining a pure cohort is important.

The criteria used in this system do not constitute a definition of schizophrenia, but rather provide an operational method for identifying patients who would be commonly considered schizophrenic in many centers, and thus permit more accurate communication and testing of clinical and research findings.

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1. American Psychiatric Association, *Diagnostic and Statistical Manual of Mental Disorders* (American Psychiatric Association, Washington, D.C., ed. 2, 1968); *Great Britain General Registrar's Office Sub-Committee on Classification of Mental Diseases: A Glossary of Mental Disorders Based on the International Statistical Classification of Diseases: Injuries and Causes of Death* (Her Majesty's Stationery Office, London, ed. 8, 1968).
2. World Health Organization, *The International Pilot Study of Schizophrenia* (World Health Organization, Geneva, 1973), vol. 1.
3. Patients were fresh admissions between ages 15 and 44. They were included for study if any of the following criteria were present: delusions, hallucinations, bizarre behavior, gross psychomotor disorder, admission diagnosis of psychosis, disorders of thinking or affect, severe social withdrawal or fear, and severe depersonalization or self-neglect. Exclusion criteria were: continuously or severely psychotic for more than 3 years; hospitalized more than 2 years of the last 5 years; presence of alcoholism, drug addiction, mental retardation, epilepsy, or an organic psychosyndrome; and presence of a severe speech or hearing disorder which would preclude evaluation.
4. World Health Organization, *International Classification of Disease* (World Health Organization, Geneva, 1965), vol. 1.
5. Similar differential diagnostic systems were developed by using Schneider's first rank symptoms, the 12 signs and symptoms with highest ratios between their schizophrenic and nonschizophrenic means, and the 12 most discriminating signs and symptoms from an analysis of variance [K. Schneider, *Clinical Psychopathology*, M. Hamilton, Transl. (Grune & Stratton, New York, 1959); W. T. Carpenter, Jr., J. S. Strauss, S. Muleh, *Arch. Gen. Psychiat.* **28**, 847 (1973)]. The results are to be published (W. T. Carpenter, Jr., J. S. Strauss, J. J. Bartko, *Schizophrenia Bull.*, in press). The 12-point system reported here was most effective in its inclusion of schizophrenic cases and exclusion of nonschizophrenic cases.
6. This report is based on the data and experience obtained during participation of the authors in the International Pilot Study of Schizophrenia, sponsored by the World Health Organization, and funded by the World Health Organization, the National Institute of Mental Health, and the participating field research centers. The collaborating investigators in this study are: N. Sartorius, T. Y. Lin, E. M. Brooke, F. Engelsmann, G. Ginsburg, M.

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Phonotaxis of Crickets in Flight: Attraction of Male and Female Crickets to Male Calling Songs

Abstract. *Large numbers of two species of mole crickets flew to loudspeakers playing the appropriate calling song outdoors. Mated females were more frequently captured than unmated ones, and males were 12 percent of the catch. Crickets of three other subfamilies were trapped as they flew to mole cricket songs resembling their own.*

Most male crickets and katydids (*1*) make species-specific calling sounds that enable appropriate mute females to find their way to them (*2*). Generally the unmated female walks or runs to the conspecific male. In the only reported case of flight bringing the pairs together, orientation to the conspecific sound occurred before flight (*3*). In studying the acoustic behavior of two species of mole crickets, we discovered that males and mated females as well as unmated females terminated long-range flights (*4*) by orienting to and landing near sources of conspecific calling songs.

Scapteriscus acletus (southern mole cricket) and *S. vicinus* (changa) are important agricultural pests in the southeastern United States. The males burrow in soil and produce calling songs in specially constructed chambers. When we discovered that flying mole crickets were landing near the entrance to the burrow where the male was singing, we broadcast a recorded calling song and dozens of flying mole crickets rained on the speaker. We studied this phenomenon in 1972 and 1973 near Gainesville, Florida, at a lighted golf course and an unlighted pasture. Our experimental setup consisted of two independent broadcast systems and three large metal funnels (1.2 m in diameter) placed 3 to 15 m apart (Fig. 1). Each broadcast system included a battery-operated tape recorder, a battery-operated audioamplifier, and a speaker (*5*). Each speaker was mounted in the center of a funnel and was aimed directly upward. A jar ring was soldered to the bottom of each funnel (5 cm in diameter), and the adults that flew into the funnels were collected in numbered 500-ml jars. The natural calling songs of *S. acletus* and *S. vicinus* were tape-recorded in the field, with the microphone 15 cm above ground level. The soil temperature was 25°C. Synthetic calling songs were made and tape-recorded in the laboratory (*6*). The intensity of the broadcast songs was measured 15 cm above the speaker (*7*) and was maintained at 100 ± 3 db during all experiments (*8*).

Broadcasting trials began about 0.5 hour after sunset and continued until most flight ended, about an hour later. Tests were made only when the soil temperature was 25 ± 3°C. During each trial both calls were broadcast simultaneously, and the trial was ended when at least one of the 500-ml jars contained 20 or more mole crickets. A predetermined duration was not used for each trial because the numbers of mole crickets flying varied greatly at different seasons, dates, and times. Trials in which no jar yielded as many as 20 mole crickets were disregarded. The jars with trapped mole crickets were detached from the funnels after

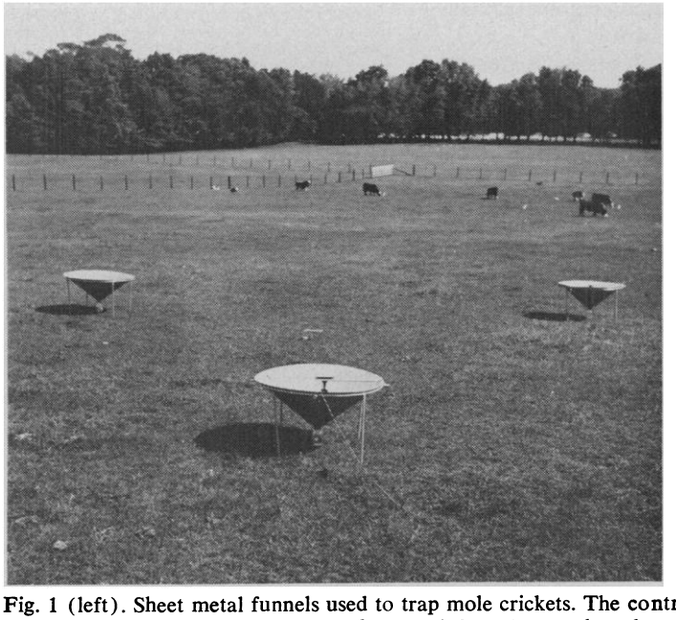

Fig. 1 (left). Sheet metal funnels used to trap mole crickets. The control trap (left back) has no speaker.

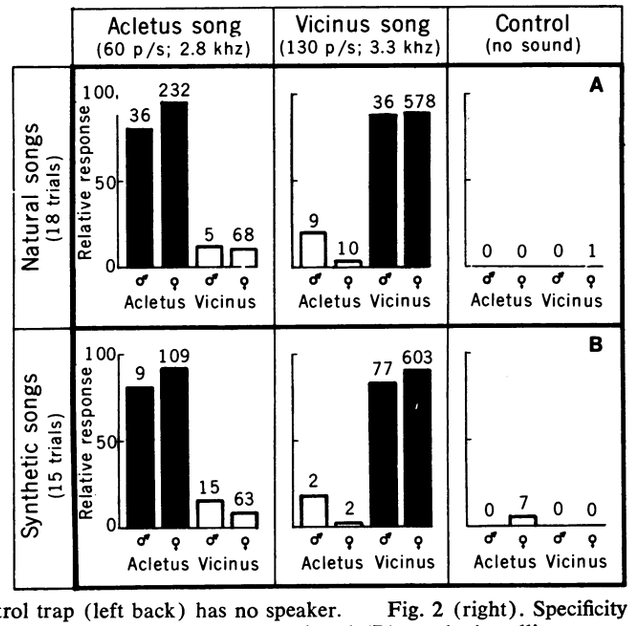

Fig. 2 (right). Specificity of response of flying *Scapteriscus acletus* and *S. vicinus* to broadcast tape recordings of (A) natural and (B) synthetic calling songs. Crickets captured in traps broadcasting conspecific songs are indicated by black bars. Others are indicated by open bars. Each bar shows the percentage of the total number of a sex and species that was captured by traps during the trials with natural songs or during the trials with synthetic songs. The number of individuals is indicated above each bar; *p/s*, pulses per second.