Pyramidical Model of Schizophrenia

by Stanley R. Kay and Serge Sevy

Abstract

Research and treatment of schizophrenia have been impeded by its heterogeneity and the lack of well-standardized methods for a comprehensive assessment of symptoms, including positive and negative dimensions. To study symptom profiles, therefore, we standardized and administered a well-operationalized 30-item psychiatric symptom scale to 240 schizophrenic inpatients. Principal component analysis suggested a pyramidlike triangular model of uncorrelated but nonexclusive syndromes that encompassed the spectrum of psychopathology. Negative, positive, and depressive features constituted divergent points of a triangular base, and excitement made up a separate vertical axis. Paired syndromes could account for symptoms of the paranoid (positive-depressive), disorganized (positive-negative), and catatonic (negative-depressive) diagnostic subtypes. The transversal positions in this model suggested polarized dimensions in schizophrenia, including a prognostic axis (depression-cognitive dysfunction). The findings imply that (1) negative and positive syndromes show factorial validity and distinction from depression but, alone, are insufficient to accommodate the full diversity of symptoms; (2) schizophrenic subtypes derive from a hybrid between unrelated but co-occurring dimensions that may define the fundamental elements of psychopathology; and (3) the pyramidical model is of heuristic value. The results help to clarify the heterogeneity of schizophrenia and to illuminate the path toward syndrome-specific treatments.

Schizophrenia has long been described as a complex and heterogeneous entity with variable symptoms, premorbid history, course, prognosis, and probably also etiology (Bleuler 1911/1950). Its nonunitary nature has frustrated efforts at understanding and treating the condition. Despite the advent of neuroleptics more than three decades ago, the early optimism has been replaced by the reality that certain persons with schizophrenia and some aspects of the disorder fail to remit. Progress in research and treatment may well require clarifying the diversity in schizophrenia, leading the way toward selective treatments for the particular syndromes encountered. The effort to describe schizophrenia has been dominated by a typological approach, on the assumption that we may recognize distinct, co-exclusive subtypes that differ in symptoms and course of illness. The schizophrenic subtypes described earlier in this century by Kraepelin (1923), while still underlying the approach to classification in American psychiatry (American Psychiatric Association 1987), has not sufficed as a basis for reaching decisions on treatment or prognosis.

One of the major advances in schizophrenia research in recent years has been the classification of symptoms as positive (productive) or negative (deficit). Crow (1980) in Great Britain proposed that positive symptoms, such as hallucinations and delusions, are associated with excessive dopamine transmission and, therefore, a neurochemical

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abnormality that is responsive to neuroleptics. By contrast, negative symptoms, such as dulling of affect and passive social withdrawal, are thought to reflect structural brain deficit and, as such, a drug-nonresponsive component that prevails mainly in the chronic phase of schizophrenia (Crow 1980; Andreasen et al. 1982). While Crow's proposition was dimensional, describing two syndromes, Andreasen and Olsen (1982) popularized the concept in the United States as a typological model, referring to positive and negative "subtypes" of schizophrenia.

Recent studies have not consistently upheld the neurobiological predictions of this model but, nonetheless, have generally supported the validity of the positive-negative distinction (for review, see Kay and Opler 1987; Pogue-Geile and Zubin 1988). For example, it has been variously demonstrated that a negative syndrome in chronic schizophrenia is associated with lesser education, greater cognitive and social deficits, a family history of schizophrenia, and an ominous course of illness (Andreasen and Olsen 1982; Dworkin and Lenzenweger 1984; Pogue-Geile and Harrow 1984, 1985; Kay et al. 1986*b*). But controversy still surrounds the questions of whether the positive-negative construct should be conceptualized dimensionally or typologically, whether it should supplant the Kraepelinian model, and how it relates to other subtypes and syndromes of schizophrenia. Indeed, despite intense studies on the criterion-related validity of the positive-negative model, the question of its *sufficiency* has been virtually ignored. In other words, the distinction could be valid but incomplete in explaining the range of schizophrenic phenomena.

Perhaps the biggest obstacle to this vital area of study has been the lack of sound psychometric techniques to measure symptoms. The available positive-negative scales have been criticized (Sommers 1985; Zubin 1985; Kay et al. 1986*a*) for inadequate operational criteria and standardization, thus failing to conform to the accepted standards of reliability and validation put forth by the American Psychological Association (1985). For example, the widely used symptom scales provide neither a standardized interview to secure information nor detailed definitions to delineate the levels of symptom severity. The item sampling is typically quite limited and not representative of all major realms of functioning, such as the cognitive, social, affective, and motor spheres. Further, the standardization studies lack data on various aspects of reliability and validity, such as longitudinal reliability and construct validity (Zubin 1985).

These fundamental considerations prompted our group to develop a more strictly operationalized and standardized instrument, the Positive and Negative Syndrome Scale (PANSS; Kay et al. 1987*a*). The procedure is based on specified information from primary care staff plus a formalized four-phase patient interview that sequentially includes nondirective, semistructured, structured, and directive segments. Patients are then rated on 30 well-defined symptoms along a 1- to 7-point severity index ("absent" to "extremely severe"), for which each rating level is individually defined per item (Kay et al. 1987*b*). Psychometric studies have supported the internal, interrater, and retest reliability of this method, as well as its content, construct, concurrent, and predictive validity (Kay et al. 1987*a*, 1988). The heuristic benefit of the PANSS, however, comes from its representation of a wide spectrum of schizophrenic symptoms that guards against a self-limited assessment. This feature is important because we need yet to explore the range of positive and negative syndromes, their relationship to one another, and their distinctiveness from other facets of schizophrenia, such as depression, which could conceivably masquerade as negative features (Carpenter et al. 1985). The broad scope of assessment permits one to consider whether the positive-negative distinction, even if valid, is a sufficient basis for explaining the full diversity of schizophrenic phenomena.

Although factor-analytic studies of schizophrenic symptoms have previously been conducted (e.g., Lorr 1962; Guy 1976), the validity of the results is necessarily limited by the validity, reliability, and comprehensiveness of the measures. In particular, since the research focus on negative symptomatology is fairly new, the earlier scales tended to include few such items. Thus, the failure of earlier factor-analytic studies to delineate a clear-cut negative syndrome may, instead of reflecting the nature of schizophrenia, simply reflect the nature of item selection. The 18-item Brief Psychiatric Rating Scale (Overall and Gorham 1962), for example, encompasses only two generally accepted negative symptoms (blunted affect and emotional withdrawal); for this reason, it does not produce a negative syndrome cluster but only an "anergia" factor (Guy 1976) that constitutes a far narrower construct.

Using the PANSS, therefore, we embarked on a large-scale study to

determine whether the 30 symptoms separate into identifiable syndromes that might clarify underlying processes in schizophrenia. Our objectives were to examine (1) the factorial validity of the positive-negative distinction, (2) its sufficiency for accommodating the full range of schizophrenic symptoms, (3) the identity of other possible components in schizophrenia, and (4) the significance of this dimensional approach for typology in schizophrenia.

Methods

Subjects were 240 schizophrenic inpatients selected from hospital settings in New York City, mainly within a State psychiatric center. All were initially screened for a chart-based diagnosis of schizophrenia and then were independently interviewed by a psychiatrist to ascertain whether they met *DSM-III* criteria for this diagnosis (American Psychiatric Association 1980). Those with major affective illness, schizoaffective disorder, organic brain syndrome, mental retardation, or any additional Axis I diagnosis were specifically excluded from the study. This sample, gathered over the course of 7 years, had been recruited for purposes of research and training and included patients in both acute and chronic phases of illness who first provided informed consent.

From the total of 240 subjects, 179 were male and 61 female; ethnically, 106 were black, 60 white, 72 of Hispanic origin, and 2 Asian. The age range was 18 to 68 years (mean = 33.1, SD = 10.21), and the duration since first psychiatric hospitalization was between 1 month and 42 years (mean = 10.7 years, SD = 8.90). All but two patients were undergoing neuroleptic treatment at the time of study and, as our data show, all were experiencing a significant array of psychotic symptoms.

PANSS ratings were performed by consensus of one to three trained psychiatrists immediately after the specified 35- to 40-minute interview. As described above, the PANSS provided a standardized method of assessing 30 psychiatric symptoms using operationally defined 7-point scales. The interrater reliability (Pearson *r*) on subsets of this sample ranged from 0.81 to 0.89 for the component scales (Kay and Lindenmayer 1987; Kay et al. 1988).

The 30 PANSS symptoms were then subjected to principal component analysis using equimax rotation to identify the distinct clusters. This statistical procedure was selected as a means of identifying orthogonal factor patterns that maximally discriminate among patients, are uncorrelated with each other, and are hierarchically ordered by their variances (Morrison 1973; Harris 1975; Marascuilo and Levin 1983). The computational technique, performed using the CRUNCH statistical program (1986), involved derivation of a correlation matrix, data reduction to a symmetrical tridiagonal matrix, and then application of a QL algorithm (Bowdler et al. 1968), with rotations, matrix inversions, and scoring calculations as per Bock (1975). By comparison to other factor-analytic techniques, principal component analysis yields latent hypothetical variables that are very closely tied to the original variables, so that component scores can later be used instead of the original variables without any loss of information (Harris 1975).

The results of this analysis, as we shall discuss, addressed four issues: (1) the factorial validity of the positive-negative distinction; (2) the identity of the major components or syndromes in schizophrenia (i.e., the statistically unrelated groups of symptoms); (3) the association of these dimensional syndromes with the established Kraepelinian subtypes (i.e., subgroups with distinctive characteristics); and (4) possible polarized axes of symptoms.

Results and Discussion

The principal component analysis disclosed seven components with eigenvalues > 1 that could account for 64.7 percent of the total variance (table 1). Of these seven components, the first four embraced a substantial set of symptoms (five or more) and had eigenvalues > 2. Thus, they were clearly distinct and, by definition of the principal component analysis (Morrison 1973; Harris 1975), were statistically unrelated. The other three components all together included only five symptoms, and these had almost as high loadings with other components (see table 2). Since these latter components are likely to be describing error variance or factors of minor influence (Harris 1975), only the first four components were retained for further analysis.

The findings confirmed the presence of unrelated negative and positive syndromes, which emerged, respectively, as components 1 and 2 and accounted for the main share of variance (36.1%). The positive syndrome, comparable to the results of Bilder et al. (1985), was restricted to items of delusions and hallucinations, while disorganized thinking was part of a separate but weaker cluster of cognitive items (table 2).

Table 1. Results of principal component analysis of 30 symptoms for 240 schizophrenic patients (pre-rotated eigenvalues > 1)

Component	Eigenvalue	Variance (%)	Cumulative %
Negative	7.08	23.61	23.61
Positive	3.74	12.48	36.10
Excited	2.55	8.50	44.59
Depressive	2.32	7.73	52.32
Cognitive	1.56	5.21	57.53
Suspicious/persecutory	1.08	3.62	61.15
Stereotyped thinking	1.08	3.59	64.73

The negative and positive syndromes, however, were indeed not sufficient to explain the phenomenology of schizophrenia. We found, in addition, a cluster associated mainly with excitement and impulsivity, and also a depressive syndrome that included symptoms of anxiety, guilt, and depression. The emergence of a distinct affective component, despite the exclusion from study of diagnosable affective and schizoaffective disorders, suggested that it is a bona fide aspect of core schizophrenia.

Although our principal component analysis identified orthogonal symptom complexes, this does not *per force* rule out a typological interpretation. The latter view, however, is less parsimonious, involving specific assumptions about the discontinuity and mutual exclusivity of these components that are not supported. Earlier typological studies on negative and positive symptoms (Andreasen and Olsen 1982; Lindenmayer et al. 1984; Opler et al. 1984) revealed only a small minority of schizophrenic patients who could be classified as showing one set of symptoms without prevalence of the other. An examination of the frequency distribution for the four components in the present study demonstrated, in fact, that negative and positive syndromes were normally distributed, consistent with our previous research (Kay et al. 1987*a*), whereas the excited and depressive syndromes were skewed slightly to the right. In all cases, however, the distribution curves were unimodal. Thus, these components appeared to represent continuous dimensions, or syndromes, rather than discrete, co-exclusive subtypes.

The interrelationship among syndromes was clarified by plotting their positions in relation to the two principal components (figure 1). We found that the positive, negative, and depressive syndromes formed divergent points of a right triangular base that encompassed the full range of symptoms. At one corner, a positive syndrome vertex was composed of the particular symptoms of grandiosity, delusions, and unusual thought content; at the second corner, a negative syndrome vertex included emotional withdrawal, blunted affect, passive/apathetic social withdrawal, poor rapport, lack of spontaneity and flow of conversation, and poor attention; and at the third corner, a depressive syndrome vertex consisted of depression and guilt feelings. The excitement syndrome, which included symptoms of excitement, tension, and poor impulse control, formed a fourth pole that brought this triangular base into a third dimension, providing the pyramidical shape that is depicted in figure 2.

The distinctiveness of these syndromes does not imply that they are mutually exclusive: a schizophrenic patient can, and in our experience typically does, show prominent features of more than one syndrome. Where two syndromes prevail, the clinical profile may be revealed by tracing the pathway between the paired poles in figure 1. The symptoms that are correlated with dual syndromes, as seen by their location between the basal points of triangulation, seem to account for the three Kraepelinian diagnostic subtypes of schizophrenia still recognized by U.S. psychiatry (American Psychiatric Association 1987).

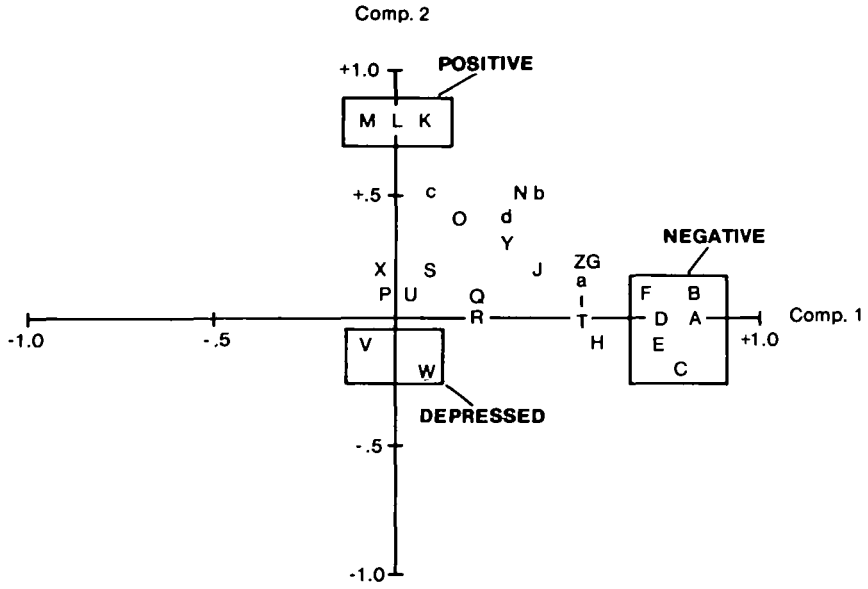
Along the pathway that connects positive and negative syndromes in figure 1, we see a concentration of cognitive abnormalities that include conceptual disorganization, stereotyped thinking, difficulty in abstract thinking, and poor judgment; these are important features of the *disorganized* type of schizophrenia. Midway along the positive-depressive poles, alternatively, we observe symptoms characteristic of *paranoid* schizophrenia—namely, ideas of suspicion and persecution, somatic delusions, and hostility. Finally, the negative and depressive poles are intersected by features associated with *catatonic* schizophrenia, such

Table 2. Means, standard deviations, and component loadings of 30 schizophrenic symptoms

Component/Symptoms	Plotting code	Mean	SD	Equimax-rotated component loadings 1	2	3	4	5	6	7
Negative component										
Emotional withdrawal	A	3.06	1.17	0.80	*	*	*	*	*	*
Passive/apathetic social withdrawal	B	2.88	1.29	0.79	*	*	*	*	*	*
Lack of spontaneity & flow of conversation	C	2.80	1.45	0.76	*	*	*	*	*	*
Blunted affect	D	3.11	1.06	0.71	*	*	*	*	*	*
Poor rapport	E	2.77	1.36	0.71	*	0.22	*	*	*	*
Poor attention	F	2.55	1.35	0.68	*	0.24	*	0.22	*	*
Active social avoidance	G	2.70	1.26	0.56	*	*	*	*	0.45	*
Motor retardation	H	1.93	1.08	0.55	*	*	*	*	*	*
Disturbance of volition	I	2.26	1.30	0.51	*	0.24	0.31	*	*	*
Mannerisms & posturing	J	1.77	1.18	0.38	*	*	*	0.26	*	*
Positive component										
Unusual thought content	K	3.54	1.50	*	0.84	*	*	*	*	*
Delusions	L	3.59	1.59	*	0.84	*	0.26	*	*	*
Grandiosity	M	2.71	1.65	*	0.76	*	*	*	*	*
Lack of judgment & insight	N	4.21	1.30	0.32	0.52	*	*	0.36	*	*
Hallucinatory behavior	O	2.75	1.66	*	0.43	*	0.39	0.25	*	*
Excited component										
Excitement	P	2.26	1.19	*	*	0.83	*	*	*	*
Poor impulse control	Q	2.08	1.15	*	*	0.71	*	*	*	*
Tension	R	2.48	1.17	0.22	*	0.66	0.39	*	*	*
Hostility	S	2.15	1.18	*	*	0.61	*	*	0.51	*
Uncooperativeness	T	2.13	1.27	0.48	*	0.49	*	*	0.38	*
Depressive component										
Anxiety	U	2.67	1.19	*	*	0.28	0.71	*	*	*
Guilt feelings	V	1.87	1.17	*	*	*	0.66	*	0.28	*
Depression	W	2.16	1.25	*	*	*	0.64	*	0.31	*
Somatic concern/delusions	X	2.54	1.40	*	0.21	*	0.60	*	*	*
Preoccupation	Y	2.89	1.15	0.30	0.32	*	0.53	*	*	0.49
Cognitive & other components										
Difficulty in abstract thinking	Z	4.14	1.35	0.52	*	*	*	0.57	*	*
Disorientation	a	1.96	1.18	0.51	*	*	*	0.56	*	*
Conceptual disorganization	b	3.33	1.49	0.39	0.48	*	*	0.52	*	*
Suspiciousness/persecution	c	3.07	1.30	*	0.47	*	0.23	*	0.61	*
Stereotyped thinking	d	2.95	1.27	0.30	0.41	0.27	0.31	*	*	0.45
Eigenvalue (%)				5.68	3.54	2.94	2.92	1.58	1.53	1.25

Note.— * = component loadings < 0.20.

Figure 1. Arrangement of schizophrenic symptoms from principal component analysis



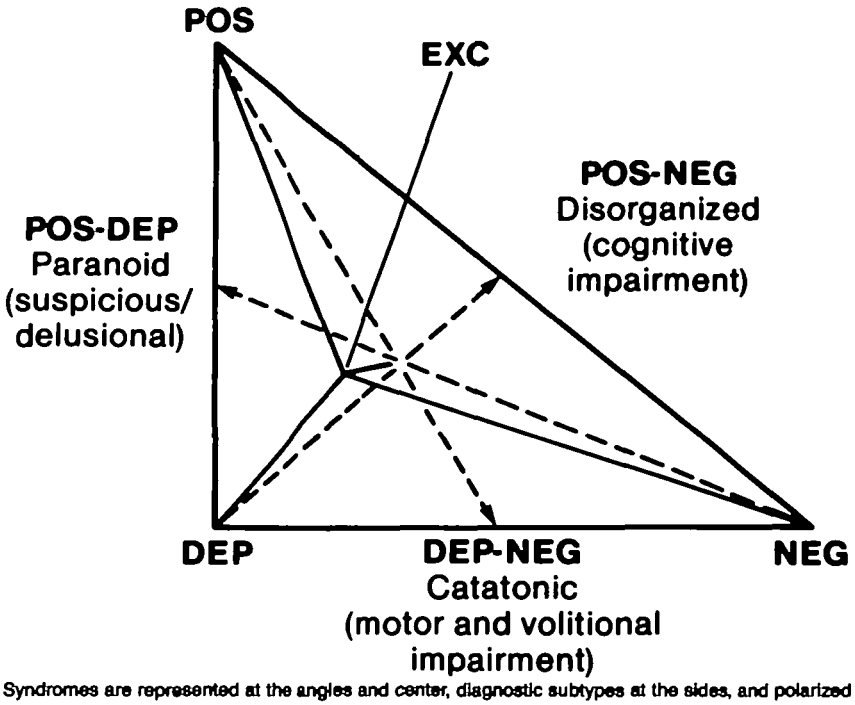
See table 1 for plotting code.

as motor retardation, uncooperativeness/negativism, and disturbance of volition.

These findings, more broadly schematized in figure 2, suggest that the Kraepelinian typology for schizophrenia derives from *hybrid* rather than pure constructs: it reflects not single pathological processes but, instead, symptoms related to paired components. Thus, we may recognize uncorrelated but co-occurring syndromes which, in their combination, produce the familiar subtypes of schizophrenia. Such a model clearly distinguishes between syndromes and typology. It argues first against regarding positive and negative symptoms as schizophrenia subtypes (cf. Andreasen and Olsen 1982) and, second, against viewing paranoid, disorganized, and catatonic features as genuine syndromes. As noted above, the paranoid type seems to comprise combined positive and depressive syndromes, the disorganized type combined positive and negative syndromes, and the catatonic type combined negative and depressive syndromes.

Within this pyramidical model, an examination of the transversal correspondence between the base vertices and opposing sides (figure 2) suggested polarized axes, or bipolar dimensions, in schizophrenia. For example, the diagonal across from the positive syndrome vertex extends distally to signs of motor and volitional impairment (figure 1). Thus, the positive syndrome stands apart in its unrelatedness to these facets of psychopathology, which bear a relationship to both negative and depressive syndromes. Analogously, the negative syndrome stands apart

Figure 2. Schematization of pyramidical model of schizophrenia



Syndromes are represented at the angles and center, diagnostic subtypes at the sides, and polarized dimensions by the tranversal arrows.

from paranoid ideation, and the depressive syndrome from cognitive dysfunction. This last relationship is particularly intriguing because of the contrasting prognostic implications of depression (favorable) (Vaillant 1964; Kay and Lindenmayer 1987) versus cognitive deficit (unfavorable) (Chapman et al. 1975; Kay and Singh 1979) in the active stage of schizophrenia. Indeed, our recent 2.7-year followup of 46 schizophrenic patients found that the best single predictors of good versus poor functional reconstitution were, respectively, symptoms of depression versus thought disturbance (Kay and Murrill 1990).

Conclusions and Future Directions

In summary, the results suggest the following conclusions: (1) There are four defining symptom complexes—negative, positive, excited, and depressive—that are statistically unrelated but not mutually exclusive. (2) These syndromes form a pyramidical set of axes that encompasses the diversity in symptoms and may reflect separate pathological processes in schizophrenia. (3) Positive and negative syndromes show factorial validity but insufficiency for a model of schizophrenia. (4) The positive syndrome, as currently conceived (Crow 1980; Andreasen and Olsen 1982), appears nonunitary, with thought disorganization not closely tied to the interrelated cluster of delusions and hallucinations. (5) The combination of dual syndromes involving the positive, negative, and depressive components may account for the paranoid, disorganized, and catatonic subtypes that are traditionally recognized. (6) The transversal relationships in this model suggest polarized phenomenological dimensions that may be relevant for prognosis and other aspects of the schizophrenic disorder. (7) From the psychometric standpoint, these data support the use of the PANSS to measure negative symptoms independently of positive and depressive symptoms, thus addressing basic concerns about the construct validity of negative syndrome assessment (e.g., Carpenter et al. 1985; Zubin 1985).

Of course, it remains to be determined whether the present findings are upheld in other samples and particularly under drug-free conditions—that is, without possible contamination from extrapyramidal symptoms. It should be noted, however, that in a recent placebo-controlled, double-blind study of 62 schizophrenic inpatients (Kay and Singh 1989), we found that positive and negative syndromes were indeed statistically independent and stable between drug-free baseline and 3-4 months of subsequent neuroleptic treatment (chlorpromazine or haloperidol).

Further research also needs to be directed at identifying the biological and historical covariates of the syndromes in this model of schizophrenia. Especially important is study of the genetic, premorbid, catamnestic, psychopharmacological, and neurobiological concomitants to consider whether the diversity in these realms corresponds to the distinct syndromes. This can be accomplished by comparing the syndromal profiles, as given by component scores on the PANSS, in schizophrenic patients who are known to differ on any one of these parameters (e.g., familial vs. nonfamilial schizophrenia). Statistically, the components bear a direct linear relationship to the original variables and, as such, serve to summarize their contribution without any loss of information (Harris 1975). Thus, on the basis of the statistical data from table 2, a patient's component scores can be calculated simply as his or her standard (z) score per item (i.e., the rated score minus the normative mean divided by the standard deviation) multiplied by the component loading for that item and averaged across the various items constituting that component.

One is indeed tempted to speculate that the negative, positive, excited, and depressive syndromes might involve different pathogenetic mechanisms. Whether or not this is the case, the present data confirm the multiplicity of symptom components in schizophrenia. The incomplete or variable response of schizophrenic patients to neuroleptic medication may be explained by its unsuitability for all these facets of the disorder; what seems needed are medications that are tailored to the particular symptom profile of the individual patient. Ultimately, our goal is to apply the pyramidical model toward elucidating the pathogenesis and treatment of this vexing disorder. We hope that our findings help to clarify its heterogeneity and, thereby, to illuminate the path toward syndrome-specific treatments.

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Acknowledgments

Portions of this study were presented before the VIII World Congress of Psychiatry, Athens, October 1989. We are indebted to Herman M. van Praag, M.D., Ph.D., and Leopold Bellak, M.D., for their critiques of an earlier draft of this article. F. Hsieh, Ph.D., provided valuable statistical consultation, and Lisa M. Murrill, M.A., Avtar Samra, M.D., and Nazma Hossain, M.D., assisted in data compilation. Participants in various phases of data collection included Lewis A. Opler, M.D., Ph.D., Abraham Fiszbein, M.D., and Jean-Pierre Lindenmayer, M.D.

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Minority Research Training in Psychiatry

The American Psychiatric Association (APA) is pleased to announce the National Institute of Mental Health's funding for the **Minority Research Training in Psychiatry Program.** This project was developed from a recognition of the critical need to train psychiatric researchers for the future and to specifically focus on the underrepresented pool of talent represented by minorities in the field of psychiatry.

The program is for medical students, psychiatric residents, and fellows. It will provide funding, including a stipend and travel expenses as well as other related training costs, for medical students to have an elective or summer experience working in a research-intensive department of psychiatry. Funding for similar experiences for psychiatric residents on an elective basis will also be provided. In addition, there are opportunities for 1- or 2-year postresidency fellowships for research training in psychiatry.

The program also includes development of a comprehensive plan for identifying medical students and residents who have an interest in psychiatric research and linking them with advisors and mentors to counsel them about a career in research. Combined with the work experience, this will provide opportunity and incentive for the medical students and residents to pursue the option of research as a career.

For further information about the Minority Research Training in Psychiatry Program, call **Harold Alan Pincus, M.D., or Jeanne Spurlock, M.D.,** at the **American Psychiatric Association, 202-682-6238.**