Most behavioral scientists believe schizophrenia is a disease of the central nervous system, but the disease is recognized exclusively by the behavior of its victims. Disorders of thinking, emotional expression, motor functioning, and social interaction are among the prominent behavioral symptoms of schizophrenia. Since there are as yet no agreed upon biological dysfunctions that are characteristic of all schizophrenic patients, a careful exploration and understanding of the behavioral symptoms can lead to the biological nature of the disease. It is not necessary for biological systems to produce specific behaviors in order for behavioral dysfunctions to be useful for understanding the biology—the pathophysiology and perhaps even the pathogenesis—of a disorder such as schizophrenia.

The behavioral sciences have recently experienced an accelerated advance in understanding many aspects of normal thinking, feeling, motor behavior, and social responsiveness. These advances are due to new techniques of investigation, new tools in exploring thought and emotion, and novel models of mental functioning that reflect a new alliance between the brain and behavioral sciences. Many of these techniques and methods are readily adaptable to studies of behavioral disorders such as schizophrenia, although a large number of them have not yet been exploited. The Basic Behavioral Sciences Panel was established to identify those findings, models, methods, and resources in order to propose a set of opportunities for advancing knowledge about the puzzling disease called schizophrenia.

Human Information Processing

Information-processing theory represents a conceptual framework of the mind which organizes the various aspects of how an individual receives, processes, and acts on information. Existing research reveals that schizophrenic subjects show deficits in virtually every aspect of elementary information processing. Schizophrenia is characterized by thought disorder, attentional vigilance deficits, selective attention deficits, hallucinations, poverty of speech and speech content, flattened intonation, illogical and incoherent speech, impaired or restricted movement, and eye movement control deficits. The incidence of motor problems also has increased as a result of neuroleptic medication.

Studies of information processing incorporate perceptual inputs, central integrative processes dealing with such inputs, and resulting performance or behavioral outputs. Central cognitive processes subsume memory, language, and complex thought processes. Performance components involve motor control and the kinematics of movement. All three components of information processing are strongly affected by the individual’s attentiveness, and therefore attentional processes have been accorded a major role in information processing.

Because of its promise for elucidating normative mechanisms and operations of information processing, behavioral research is especially relevant to the aberrant processes in schizophrenia.

Attention. Attention is the most frequently implicated component of
information-processing deficiency in schizophrenia. Such deficits range from language processing, to memory, and to motor control. Many of the desirable research directions to be enumerated are actually linked to schizophrenia through the role of attention in information processing.

Attention has been viewed as a filter blocking out unattended information. Limitation in the capacity to pay attention has been a fundamental assumption; a person has a limited ability to attend to incoming stimulation. Research has revealed that individuals' intentions and expectations and the overall context in which stimuli are embedded influence the filtering effect. A person's set or schemata can permit particular unattended inputs to filter through and undergo further perceptual and cognitive analysis and elaboration.

Attention is not a unitary process and different aspects have been identified as playing varying roles in information-processing tasks. Consider, for example, the use of such attentional facets as orienting, sustained attention, selective attention, concentration, preparation, capacity, and controlled processing. Research has disclosed that even within any of these aspects, there are a variety of different pathways depending on the modality of the incoming information. Similarly, different processes requiring the same investment of attention are unlikely to be guided by a single mechanism. Clarifying the distinctions among the various forms of attention considered earlier and examining their roles in complex tasks appear to be basic research approaches that could contribute to an understanding of schizophrenia. Such basic research and the refined conceptual models they engender could then be used in investigating tasks and processes in which schizophrenic patients are likely to be significantly impaired.

Elaborating the nature of the attentional deficit in schizophrenia might answer the critical question of whether there is actually a deficit in attentional capacity or whether the deficit is due to the competing demands of other thought processes. To the extent that schizophrenia is a thought disorder, it may be that schizophrenic patients cannot center on a task as well as normal subjects because their attention already is being shared with a competing task—namely, the disordered thinking itself.

Recent research in visual orienting, which linked its processes to their neuroanatomical substrata, illustrates the potential relevance of such behavioral research to schizophrenia. This research (involving a precise model of visual orienting at a fine-grained level of description concerning engagement and disengagement of visual attention) with both normal subjects and individuals with different types of brain damage established the neurological pathways associated with visual orienting. Thus, the engagement of attention was found to be associated with the posterior parietal lobe, the moving of attention was linked to the midbrain near the superior colliculus, and the reengagement was related to the thalamus or pulvinar. The research paradigm used successfully suggests that use of precise models of attention involving fine-grained analyses of attentional components could also be applicable to investigating linkages of attentional mechanisms of relevance to schizophrenia, one set of linkages being to their neuroanatomical loci.

Instrumentation and new techniques are available to examine time-locked responses to stimuli that are intentionally attended to and to those stimuli that attract attention because they are novel. These useful procedures include event-related potentials, which record varying brain responses that begin a few milliseconds after a stimulus is received, and autonomic and central nervous system changes, which reflect the grasping and the screening out of sense data. These latter systems include measurements of heart rate, skin conductance, pupillary dilation, and electroencephalographic (EEG) mapping.

Perception. The investigation of normative perceptual processes has stimulated development of models of perceptual operations. The most provocative and influential models of recent years (in common with models of other aspects of information processing) have emphasized network conceptualizations involving linkages of nodes or units. Such network models suggest how informational input may be perceptually encoded, elaborated on, and then recoded during processing. They also invoke a conceptualization of activation or inhibition among network units to account for processing effects.

Current studies in perception using a model called parallel distributed processing (PDP) offer a major example of models of perceptual operations. This approach assumes that at least some perception or cognition results from parallel processing that is distributed over units that are lower in hierarchical organization than the units corresponding to
the final product. The links among units constitute the site of much of the processing activity; activation and inhibition (analogous to the neurological concepts) among elements at various levels provide the means by which perceptual computation is thought to occur. An influential PDP model has been formulated for word perception, and similar models are being explored in areas of perceptual processing such as pattern perception in both vision and speech, and also with reference to category formation in the context of perceptual learning. These network models have engaged the interest of neural and computer scientists who believe that the distributed processing architecture may have some relevance to the neurological organization of at least some parts of the human brain. The quality of PDP within schizophrenic functioning would appear to offer a challenge for future investigation, especially in view of the many documented disturbances in information processing of schizophrenic patients.

**Language.** The relation between language disorder and thought disorder is still controversial. It is evident, however, that thought disorders manifest themselves in language and that language can be a useful entry point for analyzing underlying information-processing deficits of schizophrenia. Both receptive language and productive language are greatly impaired in schizophrenia. For example, speech of schizophrenic patients is less predictable than that of normal persons and is less referentially coherent. Schizophrenic patients also find "normal" speech less predictable than normal listeners do.

The analysis of perceptual and linguistic processes in reading comprehension through considering the sequence and duration of eye fixations has been an informative methodology of the past decade. Activation-based models, including those involving PDP, also have been applied to speech production. Another emerging area of language research is on the process of understanding the situation that is the topic of communication, whether spoken or written. Understanding requires having relevant knowledge, activating the knowledge, and drawing appropriate inferences to relate what is spoken or written with what is already known about the situation. Research has begun to focus on how and when inferences, including incorrect ones, are drawn.

The constructs of activation and attention, as realized in models and research on language comprehension and production, may help link some of the performance deficits in speech and understanding found in schizophrenic patients. Research using these sophisticated methodologies and models with schizophrenic patients might also help to clarify and refine diagnostic categories used in identifying schizophrenia.

**Memory.** The area of memory research is extremely large. Memory processes can be organized roughly into encoding and retrieval operations. Both children and adults use mental structures (schemata) to encode and retain complex verbal and visual materials within memory. There is increasing evidence that affect plays an organizing role in memory, but it is unclear whether this occurs through encoding or retrieval procedures.

Encoding information to be remembered requires a critical level of attentiveness. Network models of memory have greatly influenced current conceptualizations. In these models, memories are commonly represented as a set of nodes (standing for concepts that are interconnected by pathways representing relationships between them). Network models of memory postulate that once a preexisting memory node is activated, it in turn activates other informational memory nodes with which it is interconnected.

Retrieval research has gained impetus recently by studies of amnesic populations which have indicated that Korsakoff patients develop preferences and impressions though they lack voluntary access to the information on which these are based. The phenomenon of awareness of remembering also has received increasing scrutiny. The topic of "metamemory" subsumes access to the sources of remembered information, ability to distinguish between memory for experienced versus imagined events, and ability to predict eventual retrieval of currently unavailable material.

Encoding and retrieval mechanisms and the linkages between memory processes and capacity demands associated with attention, as previously noted, are promising areas of research in schizophrenia. Research on metamemory also suggests potential ties to schizophrenia, where the distinction between self-generated and actual experience is often tenuous or where there can be a lack of subjective awareness as to the basis for particular behaviors.

**Performance.** New technology has made it possible to measure kinematic parameters of movement precisely. Motor control structures
also have been modeled recently as dynamic systems, and empirical support for these has been provided by predictable and stable kinematic parameters and interrelationships. Motor control has also been modeled as a motor program; one technique involves a simple finger-tapping task. A paradigm for measuring individuals' timing capabilities for motor tasks (along with perceptual and cognitive timing) has been advanced recently, permitting analysis of subjects' tapping rhythms (matching to a preset rhythm) into components of motor output versus timing.

The relevance of the behavioral literature on controlled or skilled movements to the general issue of motor impairment remains to be explored. The applicability of motor function models to assessment of the motor impairment of schizophrenic patients subsequent to the use of neuroleptic drugs (tardive dyskinesia) also is an attractive possibility. Distinctions between controlled and involuntary movements may be of particular interest in the context of tardive dyskinesia.

Although much of the research on motor performance has looked at hand and finger performance, one of the unique advantages provided by the motor system is the opportunity to contrast anatomically distinct systems to determine their similarities and differences. Findings already indicate that common control mechanisms for distinct effector systems are frequent in the motor domain. For example, such diverse systems as speech and reaching appear to have similar general constraints, at least for normal subjects. One could therefore attempt to ascertain whether the control structures of distinct systems also are similar for schizophrenic subjects and how their parameters compare to those of normal subjects.

Alternatively, one could examine different types of motor control manifested by the same output system. For example, motor control of different oculomotor systems such as the smooth pursuit and saccadic systems could be compared. It is known that the smooth pursuit system is impaired in schizophrenic patients, but the saccadic system is not. This differential performance (at least for simple responses) may provide a way to narrow down possible neuroanatomical loci of the disease. A more systematic examination of motor systems that are and are not involved in schizophrenia also might provide a useful link to neurophysiological investigations.

**Emotional Expression**

Emotions consist of feelings, inner sensations, and changes in how one feels and acts. All psychiatric disorders in one way or another involve a disturbance of affect. While the importance of emotions has been long recognized, only recently has substantial progress been made in the direct, objective measurement of both the expressive and physiological activities that characterize emotion.

Most researchers agree that emotion involves multiple elements, including (1) information processing of events that provoke an emotion; (2) expressive and physiological changes that to some extent are distinctive for each emotion in ways that are common for all humans; (3) changes in action tendencies, such as approach or withdrawal, attack or flight; (4) retrieval of relevant memories, expectations, and methods for coping with the emotion-provoking event; and (5) subjective experience, which includes awareness of some or all of these elements. There also is agreement that emotion serves a number of functions, including motivation, self-regulation, and signaling.

The study of emotion is critical to the understanding of schizophrenia since affective disturbance is a central feature of the disorder. Affective dysfunction, for example, is a central characteristic of one main subtype—schizophrenia characterized by negative symptoms. Affective flattening is a prominent feature of this subtype and includes such symptoms as unchanging facial expression and a paucity of expressive gestures. One of the issues involved in understanding emotional flattening is whether the decreased behavioral expressivity is associated with a corresponding decrease in both psychophysiological reactivity and subjective emotional feelings, or whether these different manifestations of emotion are dissociated. The use of sophisticated behavioral and physiological measures would permit the disentangling of the various subcomponents of emotion in this subtype of schizophrenia. A second issue is diagnostic and bears on the differential diagnosis of affective disorders versus schizophrenia. The measurement of behavioral and physiological manifestations of emotion might help to differentiate between these disorders.

Until recently, research on facial signs of emotion relied primarily on the inferences and judgments about emotions that people make when they observe expressions. The lack of objective measurements of facial behavior limited progress. This situation was remedied in the 1970's with the development of anatomical-
ly based techniques for comprehensively measuring facial actions. The Facial Action Coding System (FACS) allowed the objective description of any facial expression, decomposing observed movement into the elemental muscular units that produced it, and providing for measurement of each unit’s timing, intensity, and extent of bilateral symmetry. Some of the research using FACS has already shown that facial measurements can predict the specific emotion felt and its intensity and specific profiles of physiological activity for certain emotions.

The autonomic nervous system (ANS) has long been thought to play a pivotal role in emotion, producing the visceral changes that accompany emotion. Two recent developments have dramatically advanced research on the psychophysiology of emotion: (1) It became increasingly clear that the ANS was capable of quite specific action and that different patterns of multiple ANS response channels existed for different cognitive states, coping styles, attitudes, and emotions. (2) The advent of the digital computer has permitted the efficient analysis of multiple channels of ANS data while still preserving fine-grained measurement.

Until recently, comparatively little research was conducted on the relations between neural processes and emotional behavior in intact humans despite the availability of many relevant electrophysiological, neurochemical, and nuclear methods. Some of the newest methods for assessing regional brain activation also, to date, have not been systematically applied to the study of emotion. Two major breakthroughs, however, have occurred in the past decade that have potential for advancing knowledge of the neural substrates of emotion: (1) the identification of specific neurotransmitter systems in animals that are involved in different parameters of emotional behavior and (2) the invention of new techniques for assessing regional brain activation in vivo in intact humans. For example, topographical EEG studies have shown that particular regions of the two cerebral hemispheres may be differentially specialized for certain positive and negative emotions.

Two gaps in biobehavioral research on emotion are: (1) longitudinal studies that use a combination of facial, autonomic, and central nervous system measures, and (2) subject report measures of emotion in both normal and clinical populations and in multiple sampling situations. What is needed, and for the first time actually is possible, is to study interrelationships among expressive, physiological, and subjective systems to determine: (1) how intimately they are intertwined; (2) how redundant they may be; (3) the extent to which the underlying physiology parallels the visible and audible signs of discrete emotions, and how integrated these are with the subjective sense of emotional experience; (4) temporal relationships among emotional subsystems; (5) changes occurring with maturation and aging; and (6) the degree to which cultural and social factors differentially influence each of the emotional subsystems and their interrelations.

Specific research questions with relevance to affect in schizophrenia that can and should be addressed now include the following:

- What is “inappropriate affect” in schizophrenia? Given the behavioral signs of an emotion in schizophrenia, are the subjective and physiological components also present, or is the organization of response systems that reflect emotion different in schizophrenia?
- Since affective blunting has been described as a characteristic of negative symptomatology in schizophrenia, is it a general property of all systems that reflect affect, or is it more characteristic of one system? Is the relative paucity of facial signs of emotion, observable among schizophrenic patients with negative symptoms, accompanied by decrements in autonomic and central indices of emotion, or is it accompanied by heightened autonomic arousal?
- Are behavioral and physiological measures of emotion valid predictors of the development of psychopathology in an at-risk sample? A related question is whether and to what degree any emotion-related measure can serve as a biological marker of the disorder in an examination of first-degree relatives of schizophrenic patients.
- Are behavioral and physiological measures useful in differentiating positive and negative symptomatology?
- Are there cognitive and affective asymmetries in schizophrenic patients? A growing literature suggests that left-hemisphere cognitive dysfunction may be characteristic of at least certain subtypes of schizophrenia. It would be valuable to study affective processes in patients with a demonstrated left-hemispheric cognitive deficit and compare them with patients who show no evidence of such a specific hemispheric deficit.

**Emotional Sensitivity**

There has been ample documentation of the high incidence and per-
The presence of faulty social and emotional communication in the symptom picture of schizophrenic patients is acknowledged. A review of pertinent studies reveals that problems in relationships among friends and peers are more prevalent than positive symptoms such as auditory hallucinations. Recent studies have demonstrated that when interacting with schizophrenic patients, normals dampen their affective communication in major ways—a finding that has been interpreted as due to the schizophrenic patient's high sensitivity to emotional cues from others, and consequent shutdown of communication unless emotional communication becomes muted.

Emotional communication, in the form of both encoding accuracy and decoding sensitivity, appears to play a role in schizophrenic symptomatology. It has been suggested that this conclusion is consistent with the notion of a biologically prepared hypersensitivity to certain types of stimulation which the schizophrenic person strives and often fails to screen out. It is worth noting that recent animal studies have clearly shown that both the patterning of facial and vocal expression of emotional states, and the development of sensitivity to emotional signals of others, require no social learning. This suggests that the process of emotional sensitivity is under some degree of biological control. It may therefore be possible for this biologically determined sensitivity to be influenced by the biological processes believed to play a role in the onset and severity of schizophrenia.

Most research attention to emotion in schizophrenia has been directed to the question of emotional reactivity and has neglected that concerning emotional sensitivity despite its obvious importance in schizophrenic functioning. Methodological advances and several recent developmental studies have now highlighted the feasibility and importance of studies of emotional sensitivity:

- Major strides have been made in the description of the components of both facial and vocal expression of emotions.
- Recent developmental studies on social referencing, on affective communication, and on affect attunement have shown how potent emotional signals of others are for the regulation of behavior; these investigations have provided promising methods for the study of the behavioral consequences of emotional signals of others.
- Important statistical contributions have been made that will help avoid many of the analytic pitfalls of prior research on coding sensitivity.

With the above developments as background, a recent conference convened by the National Institute of Mental Health (NIMH) (August 1987) offered a number of research recommendations relevant to schizophrenia:

- The possibility should be considered that the scores of a decoder of an emotional message partly reflect the unique sensitivity of the decoder to the signals of one specific encoder or model. Most prior work has used only one model or situation. A new analytical scheme, however, is a promising development that does justice to the complexities of emotional communication. This arrays the encoding and decoding of several persons to one another, thereby providing a less biased evaluation of sending and receiving accuracy.
- Careful measurement of the encoder's social signals should be performed to determine whether individual differences in decoding are a function of detecting the presence of an emotion in a blend of several emotions, or whether differences in decoding are a function of other factors besides the nature of the signal presented to the receiver. The question to pose is whether there are individual differences in schizophrenic patients to the presence of social signals in the expressions of another.
- Analyses of the types of errors made in studies of receiving accuracy should be performed. Schizophrenic patients have been reported as not being uniformly insensitive to emotional signals from others. Failure to break down errors into discrete emotional classes may obscure important sensitivities and deficits.
- Whether the pattern of errors shown in identifying facial and vocal expressions of emotion is sensible or bizarre should be ascertained. For example, subjects with neurological damage confuse such negative affects as fear and anger which are emotions close to each other, whereas schizophrenic patients may make bizarre errors such as coding a joy state as sadness.
- The socialization of emotions should be studied across cultures and groups.
- An emotion quotient scale involving sensitivity to others' signals should be developed to help identify aberrant emotional development and determine how predictive it is of later pathology.
• Behavioral genetic methods should be used in studying emotional sensitivity (e.g., in twin studies) to help elucidate possible underlying biological factors and their relationship to individual differences in emotional sensitivity.

Social Relations and Interpersonal Behaviors

Many schizophrenic patients have difficulties in their interpersonal behaviors and are often withdrawn in their social relationships. The majority of studies on the social interactions of schizophrenic patients agree that, regardless of the chronicity of their illness, they interact at a rate lower than that of nonschizophrenic persons, even those diagnosed as having other major psychiatric disorders. More data, however, are needed as to the extent that social functioning varies with different schizophrenic symptom states. Also, deficits in the interpersonal functioning of schizophrenic patients may not necessarily be an integral part of the psychotic episode itself. Rather, such deficits may be a secondary effect of the schizophrenic symptomatology or a prepsychosis potentiating condition indicative of vulnerability to schizophrenic episodes.

Various investigators during the past two decades have focused on the social relations of individuals identified as preschizophrenic or as being at high risk for later schizophrenia. Several studies relying on archival data have reported somewhat similar findings. Preschizophrenic persons tended to be poorer in childhood social competence than were those who developed other disorders or those who did not become psychiatrically impaired. Preschizophrenic girls were more introverted and passive, while preschizophrenic boys were more disagreeable, unpleasant, uncooperative, inconsiderate, and poorly behaved. Results from mostly cross-sectional studies of children considered at heightened risk for later schizophrenia (e.g., children born to a schizophrenic parent) as compared to low-risk peers have suggested that the interpersonal competencies of the high-risk children generally are poorer.

There is new evidence to suggest that children’s peer relations as indexed by sociometric status are a good prognostic indicator of a variety of later disorders, including schizophrenia. Two important dimensions appear to be rejection by peers and neglect or social isolation. In the last decade, there have been significant advances in determining correlates of these two patterns of problems that children have with their peers. This progress has been made in four areas: (1) the study of general interaction has been abandoned in favor of the study of children in important but low-frequency events such as peer entry; (2) the study of social behavior has been fruitfully combined with the study of social cognition; (3) it has proved productive to search for familial correlates of a child’s sociometric status and the style of peer interaction; and (4) epidemiological studies have identified the best prognostic indicator of later deviance as the shy-withdrawal syndrome.

The early and simplistic view that sought to identify parents as causing schizophrenic disorders, particularly the so-called schizophrenogenic mother, generally has been discredited. The demonstrated association of toxic environmental factors does not establish direction of casualty. What it does establish, however, is a need to pursue harmful factors as well as those which may prove protective.

Three types of environmental factors have proved illustrative:

• Expressed emotion—an environment characterized by criticism, hostility, and interpersonal involvement.

• Communication deviance—an environment characterized by an inability to share a common focus of attention, to take another’s perspective, and to communicate clearly and accurately.

• Negative affective style—an interactive style characterized by harsh criticism and/or intrusiveness.

One caveat about these environmental factors needs to be emphasized: Although all have been studied in the context of the family, we should not confuse association with causality. Indeed, these findings may well eventually tell us more about schizophrenia than about family life. Clearly, environmental factors need to be pursued, but the family environment should not become the sole focus of this work, as the family is not the sole environment in which the person suffering from schizophrenia operates. In fact, the application of these environmental factors has recently been introduced into the development of psychosocial treatment programs and may contribute to our understanding of why some interpersonal therapies may prove overstimulating and indeed toxic for some patients.

The following research questions can now be addressed concerning social or interpersonal aspects:
A full range of environments should be studied building on the promising leads currently available. Such environments should include peer and educational exposures from early childhood through adolescence, and work and living environments in young adulthood. Further, the results of this work should be carefully integrated into treatment environments in both short- and long-term recovery programs.

Research should focus on the schizophrenic person’s processing of emotional events, particularly criticism and other negative affects in the context of family and peer interactions. A social-psychophysiological approach is required that integrates observational measures with self-report, EEG, and ANS variables. Research should address whether the observable information-processing deficits of schizophrenic patients are employed in the service of protecting them from negative affective stimuli in the context of social interaction.

**Personality**

Individual differences in psychosocial, emotional, and other behavioral patterns can be defined as differences in personality. These personality differences are thought to influence the vulnerability and resilience or hardiness of individuals at risk for schizophrenia. They may affect specific expression of illness, time of onset, long-term course, and quality of intermorbidity adjustment. Specific vulnerability or protection factors may be associated with particular personality characteristics. Definitive examinations of these possibilities remain to be carried out through prospective and followup studies of individuals at risk, together with parallel studies of appropriate comparison groups.

Methodological developments of the last one or two decades in personality measurement, as well as greater clarity about aspects or domains necessary for inclusion in research on personality in schizophrenia, can guide future studies. Schizophrenia is often said to be characterized by failing social and integrative functions. Personality descriptors therefore must be chosen to represent social and integrative variables as broadly as possible so that the descriptive data themselves can show the natural demarcations of the disorder. Descriptors are best chosen from both the “normal” personality domain and from psychopathology.

Studies with normal subjects have indicated the importance of incorporating both “O-data” (personality ratings provided by observers) and “S-data” (self-descriptors provided by the person). The perspectives represented by these two different data domains overlap, but there appear to be distinctive differences even in dimensional structure. It is crucial to chart possible differences between these domains in the study of schizophrenia. In the O-domain, when normal subjects have been studied, the emergence of the following five major dimensions has been a striking and replicated phenomenon: extraversion, agreeability, conscientiousness, emotional adjustment, and culture. These dimensions require clarification and supplementation but may prove to be useful predictors in their own right when applied to assessment in schizophrenia. In addition, they provide a baseline against which the incremental validity of more fine-grained descriptors can be assessed.

In the S-domain, more differentiated dimensional structures are already available. A number of personality inventories have been developed in recent years that provide assessment in such areas as emotional temperament, impulse control, and social behavior. For example, it is now possible, using existing instruments, to distinguish between positive and negative emotional parameters. The distinction between negative and positive emotions may be crucial for differential predictive purposes in schizophrenia (with its manifestations not only of negative emotions such as anxiety and anger but also of impoverished positive emotionality). Negative emotional turmoil may prove to be less unfavorable over the long term than a pervasive deficiency in positive emotionality. Yet, a clear distinction between these two dimensions of affect and temperament has not yet been fully assimilated in clinical assessment.

Although the field of personality assessment is a source of well-defined structures on a basic descriptive level, it does not yet directly concern itself with assessing personality integration. Integration is crucial to understanding personality disorders and serious mental illness. Personality characterization is incomplete if it fails to assess integration. An important development in this direction is the intensive effort of the past 15 years to assess psychological development as a high-order integrative personal parameter. According to Loevinger’s conception and measurement of ego development, individuals can be placed on a developmental continuum of ego maturity. Each developmental level is typified by a characteristic orienting “frame of
reference” which allows the individual to assimilate experiences into a coherent cognitive structure.

Within the boundaries of the normal personality domain, the working assumption has been that individuals differ only in developmental level of maturity, not in the very ability to form an orienting frame of reference at some level, low or high. This assumption underlying the work of Loevinger and others has been heuristically useful in developing the procedures for assessing developmental level. Now the time may have come for exploring the possibility of formally assessing variations in the capacity itself for forming and sustaining coherent frames of reference. Although traditional projective tests have long been used for this purpose, the necessary methodological and conceptual tools have not been available until recently. The sophisticated work by Loevinger and a few others appears to have laid the groundwork for changing this picture. By using Loevinger’s sentence completion methodology, for example, as a point of departure, it may be possible to begin differentiating expressions of psychological immaturity without loss of the individual’s basic ability to form an integrating frame of reference, although integration may be at a relatively low level) from integrative deficit or vulnerability. Thus, an individual may achieve episodes of great maturity and insight even if personality integration is fragile. Although maturity and integration are interdependent, a distinction between these two characteristics appears important and may have become both a conceptual and psychometric possibility.

The domain of psychopathology provides a wealth of descriptors for use in assessment. For example, the DSM-III diagnostic classification scheme and its revision contain a large number of relevant symptomatic variables, both in the Axis II and Axis I sections. What the diagnostic manual does not provide are empirically confirmed syndromes and dimensions. Thus, the DSM-III personality disorders appear to have been defined largely on the basis of consensual methods through reliance on the opinion of experts. In a program of empirical research, a source such as DSM-III may be used as a thesaurus of descriptors but cannot be a substitute for empirical techniques in deriving the inherent syndromal and dimensional structure underlying symptoms.

It should prove informative to determine the extent that psycho-pathological personality variables, as found in schizophrenia, define dimensions over and beyond the normal personality domain, and to what extent the assessment of integration, alluded to earlier, proves to play a critical role. A broad-spectrum study of these descriptive domains in relevant at-risk, patient, and normal populations is indicated. Informative studies of personality factors as modulators of schizophrenia and schizophrenia spectrum disorders will involve more than the application of ready-made measures and concepts. A genuine contribution will also require the development of appropriately adopted or new measures and concepts attuned to the intrinsic features of schizophrenia.

Genetics, Behavior, and Schizophrenia

Genetic variation is a basic fact of life in health and disease. It now is generally accepted that schizophrenia runs in families. Most researchers consider that the studies of family prevalence, together with twin concordance and adoption studies, indicate genetic transmission of schizophrenia. The mode of genetic transmission is nevertheless uncertain due to the low prevalence of schizophrenia within families. The risks for schizophrenia in families of schizophrenic probands are lower than for classical Mendelizing traits.

The mode of transmission of schizophrenia is at present indeterminate and debatable. There are advocates of either a multifactorial polygenic threshold model or of some version of a single locus major gene. It may be, however, that it is not so much the mode of transmission that is indeterminate but the entity that is transmitted. If the DSM-III schizophrenia diagnosis is fixed upon as the trait of genetic interest, then the heterogeneity of this phenotype greatly confuses the search for the transmission model. Adherence to the DSM-III diagnosis as the transmitted trait may keep the geneticist from exploring the fertile territory that opens up when the investigator studies specific traits and characteristics—relatively small units of behavior that may be closer in sequence of causation to the genetically transmitted factor. No laboratory in vitro test exists for making an infallible diagnosis of either clinical schizophrenia or of the subclinical personological, biological, psychophysiological, or neuroanatomical “carriers” of the relevant genotype. But there is reason for optimism since there are a few promising candidate markers and indicators currently under investigation.
While genetic studies of schizophrenia at the molecular level remain a basic research strategy, it is essential simultaneously to pursue a parallel research track that is epidemiological and sociopsychological in nature. Such studies address questions of what it is in the environment that may trigger, aggravate, or maintain a schizophrenic disorder. There are no studies that have yet presented definitive evidence of specific or particular environmental factors that have been identified as producing schizophrenia— invariably or even with moderate probability. These include ecological and familial- psychodynamic environmental variables. There seem to be, however, aspects that assume importance for exacerbating schizophrenia, or maintaining it once it has begun.

The following behaviorally relevant issues or topics must be considered in genetic research:

- **Populations and size of families.** Family genetic analyses which have been informative for Huntington’s disease and manic-depressive illness involve two- to three-generation pedigrees with many affected and available relatives. These families are exceedingly rare for schizophrenia research as long as only overt cases are counted as informative. The concept of pleiotropy holds that a gene product has a multitude of “downstream” effects, and it is not until the pathophysiology of a process is identified that the relationships among symptoms can be identified. Therefore, in schizophrenia research, multiplex families are not the only ones to be sought. Families with only one or two cases may prove to be very informative.

- **Diagnostic conventions.** Clinical studies of the relatives of schizophrenic patients show that too narrow or broad a diagnostic orientation will erode the needed information about the presence or absence of psychopathology. Optimal assessment of relatives requires a multidimensional approach involving the best that biology and psychology can offer. There probably are a number of different trait dimensions, not all of which are psychiatric, in which the influence of genetic factors can be detected. It probably is prudent to widen the number of dimensions along which relatives are examined. The current nosology of schizophrenia and schizophrenia-related psychopathology consists of conventions that are far from ideal for use in research. Investigators should feel free to adopt a polydiagnostic approach. In light of probable pleiotropic effects in schizophrenia, the dichotomy of positive and negative family history may be counterproductive for genetic research. Genes can be present and yet unexpressed. Medium-sized families may be quite appropriate for preliminary genetic studies if investigators possess bona fide “indicators” or “markers.”

- **Use of markers or indicators.** It is important to distinguish between the use of such variables for linkage analysis and for studying expression of the disease itself. Some traits may be observable only after a challenge. Some indicators may be represented by personality dispositions, thinking disorders, subtle dysfunctioning of some cognitive processes (e.g., attention or iconic storage) or affective processes (e.g., emotional repertoire or qualitative range of emotions). Candidate allele markers, logically selected from knowledge about the neuropharmacology of schizophrenia, and studied by techniques of molecular genetics, are very much in their infancy. Other indicators include eye-tracking dysfunctions and certain parameters of event-related potentials. The candidate indicators in cognitive (attentional) tasks still require extensive testing in the families of schizophrenic patients, including the unaffected relatives. Normative data are also required on all measures used to provide standards against which to judge deviation. There is a need for a broader search for indicators than the qualitative and quantitative variations represented in symptom assessments. More probing descriptions and observations of all members of the family can be informative and enrich the categorical approach represented by the DSM-III guidelines.

Once the gene is known and its presence can be detected, it is important to study its effects. This can be done by testing normal persons who are unrelated to schizophrenic patients as well as the other apparently unaffected relatives of schizophrenic patients in order to search for pleiotropic effects and behavior.

While most genetic studies rely on molecular biological techniques, studies of mental diseases such as schizophrenia, whose manifestations are clearly and principally behavioral, may profit extensively from parallel studies that make use of basic behavioral techniques. The use of behavioral tests in a program that has a molecular biological goal may at first seem puzzling. But if schizophrenia is a brain disease, its manifestations should be present in behavior, and probably in subtle
deviations in behavior. The use of psychological observation provides power and sensitivity. Broad instruments (like the continuous performance test) as well as probes of specific processes (like chronometric indicators of engagement of attention or eye-movement measurements) are both needed. These measurements may be more sensitive to genes for schizophrenia than the assessment of EEGs or biological fluids. It is not necessary that there be genes that code directly for behavior for a study of behavior to be useful in genetic studies.

**Primate Models of Schizophrenia**

Primate models of schizophrenia place major emphasis on producing compelling behavioral analogs to the constellation of symptoms that characterize the human disorder. There are necessary limitations to such models; yet they have potential value. It is unlikely that a “perfect” model or models can be developed in which all subjects under study ultimately come to display the full range of symptoms characteristic of schizophrenia. Instead, major individual differences among at-risk primate subjects can be expected and deviation from known human patterns should be tolerated to some degree. Primate models of schizophrenia should not be confused with the actual human disorder but used to reproduce certain characteristic features of the human phenomenon for careful study under conditions of control not possible in human studies.

The purpose of primate models, therefore, is not necessarily to draw explicit conclusions about schizophrenia but (1) to permit development of new therapeutic techniques for subsequent testing with humans; (2) to test hypotheses about etiology and maintenance of the disease that are difficult, impossible, or ethically unacceptable to test in a controlled fashion with humans; and (3) to set the priorities for hypothesis testing at the human level.

There are a number of specific considerations concerning types of behavioral end points that might be incorporated into evaluations and use of primate models of schizophrenia. A common assumption of the past should be noted to the effect that certain features of schizophrenia cannot be modeled at all. These judgments often have been ad hoc decisions as opposed to the results of empirical efforts. Many of these judgments, if made now, would fail to appreciate research developments and the techniques that have been crafted in recent years for the study of nonhuman primates. Using the DSM-III and NIMH Diagnostic Interview Schedule, one can consider elements listed under the heading of “characteristic delusions, hallucinations, or thought disorder.” Previous models, in particular those involving chronic amphetamine administration, have already provided compelling evidence of visual and tactile hallucinations. The lack of auditory hallucinations, a more prevalent feature of human schizophrenia, has been an important criticism of the amphetamine psychosis model. This, however, is not an intrinsic difficulty. It is now clear that monkeys can be trained on differential auditory discrimination problems in avoidance and/or appetitive situations. This permits a comparison of the ambient expression of auditory-based behaviors before and after any schizophrenic induction procedure.

Similarly, recent developments in the use of color video stimuli with primates offer possibilities for assessing how evaluation procedures elicit schizophrenic-like symptoms in primate subjects. Determination of the degree to which subjects misinterpret static, moving, and social stimuli could all be tested using videotaped stimuli in a variety of operant and passive response settings. It has been demonstrated that “normal” monkeys and apes respond differently, for example, to taped representations of same versus other species, strangers versus familiars, and fear-inducing versus curiosity-inducing stimuli. Friends and enemies also are readily differentiated by these subjects. How these specific patterns of response to social and related stimuli, all quantitatively determined, are altered as a result of the induction procedures could well provide important parallels to the disruption in stimulus interpretation seen in human schizophrenia.

The use of a range of responses to altered stimuli, the availability of distorted and degraded stimuli, and the capability for determining whether amorphous stimuli are attributed from specific features as reflected in differentiable responses are all feasible in this mode of testing. Alterations in the pattern of response to these carefully controlled and replicable stimuli could open up a large range of function for investigation in modeling information-processing aspects of schizophrenia in these animals. Moreover, since many of the symptoms of schizophrenia relate to problems in the initiation and reception of communicative signals, both
visual and auditory video programs are extremely promising avenues of investigation in this area.

One indicator of psychological disturbance in humans is the degree to which a person's behaviors match the normative patterns observed in other similar types of subjects in complex, demanding situations. Observational studies of primates offer the possibility of studying behavioral change and breakdown. Over the past 30 years, primatologists have devised a number of systematic schemes to provide quantitative data on the behavior of individual subjects in complex settings. Changes in response to family members, close associates, and allies, as well as those above and below the subject in the dominance hierarchy, may all herald the emergence of the modeled disorder. Similarly, the subject's interaction with the environment, distractibility, and/or breakdown on foraging patterns and efficiency, exploratory and withdrawal behavior, and responsiveness to real and apparent danger may all be compared to the parallel behaviors simultaneously seen in nontreated subjects. Thus, in the context of such settings, the effects of induction techniques can be evaluated through comparison of primate subjects to their peers in the same situation (or to their own behavior before the manipulation) instead of directly to some presumptive template of disorder.

**Research Resource Needs**

If the above substantive research areas and techniques are to contribute to an improved understanding of the clinical phenomena of schizophrenia, there must be increased interaction, understanding, and collaboration between basic scientists and clinicians. This was a pervasive theme throughout the discussions of the Basic Behavioral Sciences Panel. Not only is there a need for basic researchers to be able to apply their techniques to clinical populations, but there is a need to (1) acquaint interested behavioral sciences investigators with the phenomenology, clinical questions, hypotheses, and problems relating to schizophrenia; (2) encourage clinicians and clinical investigators to become more conversant with the range of basic behavioral sciences methods, as well as the body of existing substantive research data, which are applicable to the study of schizophrenia; and (3) develop means for facilitating interaction and collaboration among them.

Workshops or seminars are one way to acquaint basic scientists with schizophrenia research and phenomena. Such meetings, in which schizophrenia research and needs are discussed and schizophrenic patients are described or presented, would have a very positive effect in familiarizing basic researchers with issues, problems, and research opportunities and would thereby foster collaborative research efforts involving basic scientists and clinicians. Similarly, workshops to increase the familiarity of clinical investigators with the basic behavioral sciences would be helpful. Such workshops optimally would be of 3-day length and limited to about 12 participants. Other initiatives to facilitate increased cross-knowledge and interaction that should be considered include the following: (1) special or increased funding of post-doctoral fellowships specifically to allow both beginning and experienced basic investigators to work in clinical settings; (2) grants designated for collaborative work involving basic researchers and clinicians; and (3) funds to encourage and facilitate long-term visits of basic researchers and clinical investigators to each others' laboratories or settings.

Another general concern of the Panel was the increasing difficulty of conducting research with primates. Recent severe limitations on exports of primate species by several foreign governments, development of unnecessarily restrictive U.S. legislation on use of animals in research, and continued activity and harassment by animal rights groups have combined to make primate research extraordinarily difficult and expensive. Animal research in general, and primate research in particular, are crucial to both biological and behavioral advances in schizophrenia. The current situation poses a serious threat to this field of research. What seems to be needed is an organization similar to the National Association for Biomedical Research, but with a somewhat narrower focus on biobehavioral studies with primate subjects. Efforts should be made to enhance breeding programs in the United States as well as in foreign countries where one can take advantage of native habitats. And, the National Institutes of Health should undertake a major increase in the breeding capacities of the existing Primate Research Centers.

**Suggested Readings**

Alexander, G.E.; Delong, M.R.; and Strick, P.L. Parallel organization of functionally segregated circuits linking basal ganglia and cortex. *Annual
Kety, S. The syndrome of schizophrenia: Unresolved questions and


