# Information Processing and Attentional Functioning in the Developmental Course of Schizophrenic Disorders

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## Abstract

This article examines the evidence that certain deficits in information processing and attentional functioning are present across populations at risk for schizophrenic disorder, with active schizophrenic psychotic symptomatology, and in relative remission after a schizophrenic psychosis. In addition, the evidence that some deficits in processing information occur only in the actively psychotic period is inspected. Deficits in vigilance tasks with high-processing loads, in forced-choice span of apprehension for large arrays, and in serial recall for items that involve active rehearsal occur across risk populations, actively symptomatic schizophrenic patients, and relatively remitted schizophrenic patients. These deficits may reflect vulnerability factors for schizophrenic disorders. Reaction time crossover, dichotic listening, backward masking, and referential communication deficits might also be vulnerability indicators. These deficits may be related to a reduction in the processing capacity that is available for task-relevant cognitive operations in persons vulnerable to schizophrenic disorder, which could, in turn, be caused by several different underlying cognitive anomalies. Cognitive deficits that have been found only during actively psychotic periods or in chronic schizophrenic patients, such as poorer recognition of briefly presented, single, familiar letters or numbers, are characterized by low demands on processing capacity. These deficiencies may be caused by further reduction in available processing capacity or a temporary disruption of automatic as well as attention-demanding processes; they could also reflect a stable, more severe cognitive deficit in a subtype of schizophrenic disorder.


Eugen Bleuler described the lack of cognitive control displayed by patients with schizophrenic disorder when he noted they were "incapable of holding the train of thought in the proper channels" (Bleuler 1924, reprinted 1976, p. 377). Using a terminology that predates the development of modern cognitive psychology and information-processing models, Bleuler hypothesized that most schizophrenic symptomatology could be traced to a "disconnecting of associative threads" that form the relationships between ideas (Bleuler 1911, English translation 1950, p. 21). The weight that Eugen Bleuler placed on cognitive dysfunction in schizophrenia is evident in his inclusion of associative disturbance among both his lists of fundamental symptoms (present in every case) and primary symptoms (directly caused by a hypothesized underlying organic process). Although major difficulties in developing operational criteria for this "disconnecting of associative threads" or "looseness of associations" have led to decreased dependence on this disturbance for diagnostic purposes (World Health Organization 1975), the prominent role that Bleuler gave to a basic cognitive dysfunction has had a major influence on studies of psychological and psychophysiological deficits in schizophrenic disorders. The proposition that primary malfunctions in elementary cognitive processes contribute substantially to formal thought disorder continues to be a viable one. Moreover, some investigators (e.g., Hemsley 1977; Frith 1979) have extended this connection in Bleulerian fashion to

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include ties between a cognitive deficit and the secondary formation of delusions and hallucinations. Thus, although certain forms of delusions, hallucinations, and thought interference in the absence of a major affective disorder syndrome have become the central diagnostic criteria for the *DSM-III* diagnosis of schizophrenic disorder (American Psychiatric Association 1980), the question of whether some or all of these psychotic symptoms reflect disturbances in more elementary cognitive processes remains a live one.

The inadequate control over the continuity of thought in schizophrenic disorder that Bleuler noted has seemed to many investigators, including Emil Kraepelin, to be associated with disordered attentional processes: "This behavior is without doubt nearly related to the disorder of attention which we very frequently find conspicuously developed in our patients. It is quite common for them to lose both inclination and ability on their own initiative to keep their attention fixed for any length of time" (Kraepelin 1913; English translation 1919, pp. 5–6). Kraepelin distinguished between "Auffassung" or registration of information, which he felt was generally intact, and "Aufmerksamkeit" or active, sustained, or directed attention, which he felt was almost always deficient in schizophrenic disorder (Holzman, Levy, and Proctor 1978).

The distinction between intact registration of information and impaired active, sustained, or directed attention that was made by Kraepelin represents an early attempt to delineate the type of information processing that malfunctions in schizophrenic disorder. More recent experimental efforts to distinguish the nature of schizophrenic cognitive impairments have profited from the development of information-processing models within cognitive psychology and cognitive neurosciences. Although considerable disparity remains among these information-processing models in the details of specific types or levels of processing, they do provide a more differentiated terminology for description of elementary cognitive processes than was available earlier.

Another current trend in research on cognition, perception, and attention in schizophrenic disorders is a focus on determining whether deficits displayed by actively psychotic schizophrenic patients are also present before the onset of the psychotic episode and remain after the remission of acute psychotic symptoms. Some enduring, trait-like dysfunctions might be genetically influenced aspects of vulnerability to schizophrenic disorders. Thus, a related development is the burgeoning interest in isolating deficits in processing of information among first-degree relatives of schizophrenic patients, a population that is at heightened risk for schizophrenic disorder. These developments are the result of increasing recognition that studies of actively psychotic schizophrenic patients can clarify the structure of the psychopathological state but might not elucidate the developmental processes leading to such episodes (Garmezy and Streitman 1974; Nuechterlein, in press *a*). Furthermore, findings based solely on studies of actively psychotic schizophrenic patients may be confounded by common secondary concomitants of the disorder, such as hospitalization, medication, social stigma, and demoralization (Mednick and McNeil 1968). Thus, a focus on anomalous processes that characterize individuals at heightened risk to develop schizophrenic disorder (Mednick and McNeil 1968; Garmezy 1974) and individuals in remitted states after schizophrenic episodes (Wohlberg and Kornetsky 1973; Asarnow and MacCrimmon 1978) should help to identify abnormalities that have a more enduring role in schizophrenic disorder than the psychotic symptoms themselves. This research strategy represents an empirical means by which certain basic phenomena contributing to schizophrenic psychotic periods might be distinguished from abnormalities that are part of or secondary to the psychotic state.

The differentiation between transient and enduring abnormalities relevant to schizophrenic disorder was highlighted by the distinction proposed by Zubin and Spring (1977) and Cromwell and Spaulding (1978) between symptom-linked states or episode markers, on the one hand, and vulnerability-linked traits or vulnerability markers, on the other. Spring and Zubin (1978) and Zubin and Spring (1977) designated as potential markers of vulnerability to schizophrenic disorder those performance abnormalities that met the following criteria: (1) The abnormality is present in both schizophrenic patients and their nonaffected siblings and other blood relatives, but not in healthy control individuals or nonschizophrenic psychiatric patients, and (2) the abnormality persists in "recovered" schizophrenic patients. They argue that anomalies that show no relationship to the manifest psychopathological state, but which characterize both "recovered" schizophrenic patients and their relatives, are likely to be associated with the underlying vulnerability to schizophrenia. On the other hand, Spring and Zubin (1978; Zubin and Spring 1977) propose that abnormalities which occur only in

highly symptomatic schizophrenic patients and which normalize in retested "recovered" cases should be considered episode markers.

The purpose of this article is to evaluate the evidence on the role of information processing and attentional dysfunctions in the developmental course of schizophrenic disorders, with emphasis on the differentiation between enduring vulnerability indicators and temporary, symptom-linked, episode indicators. The focus will be on those information-processing and attentional tasks and variables for which data are available for periods before, during, and after active schizophrenic psychosis. Because no highly reliable and valid procedure for identifying specific preschizophrenic individuals prospectively is currently available, populations at heightened risk for schizophrenic disorder are examined for possible indicators of abnormalities that precede schizophrenic psychosis. Our focus on tasks and variables that have been studied across these types of populations will result in a highly selective treatment of the vast literature that examines cognitive performance deficits through cross-sectional comparisons of actively symptomatic schizophrenic patients and comparison groups. For evaluations of various aspects of that literature, the reader is referred to Chapman and Chapman (1973), Cromwell (1975), Nuechterlein (1977*a*, 1977*b*), Venables (1978), Magaro (1980), Neale and Oltmanns (1980), and Kietzman, Spring, and Zubin (1980).

The current article is divided into five sections. First, an overview of some current concepts and models of information processing and attention within normal individuals is presented to provide a background and terminology for discussion of the studies of schizophrenia. Second, the evidence for various information-processing and attentional deficits in preschizophrenic and high-risk individuals is assessed in some detail. Next, a selective review of cross-sectional differences between schizophrenic and normal subjects (and other comparison groups, when available) focuses on tasks and variables that have also been used with remitted schizophrenic patients and populations at heightened risk for schizophrenia. Fourth, we evaluate the extent to which similar deficits remain among remitted schizophrenic patients in the absence of psychotic symptoms. Finally, the role that such dysfunctions during active schizophrenic periods may play in predicting the course of illness is discussed. In a final article within this series (Nuechterlein and Dawson 1984), we attempt to describe tentative heuristic schemas by which this evidence and that from the other substantive areas that are reviewed (autonomic dysfunctions, interpersonal deficits, familial attitudes, and extrafamilial stresses) might be combined in conceptions of schizophrenic episodes.

## Current Concepts of Information Processing and Attentional Functioning

Rapid advances in information-processing models of normal human cognition have led to more fully elaborated conceptions of sensory, perceptual, and conceptual processes that normally intervene between stimulus and response. Researchers in this large and active research field will, of course, continue to revise currently available models of normal human information processing, and an outline of developments in this area is necessarily highly selective and cannot do justice to the complexity of the field. Nevertheless, these developments are helpful in delineating contemporary and possible future issues relevant to abnormalities in schizophrenic information processing.

**Stage Models of Information Processing.** One form of information-processing paradigm that greatly influenced the development of current conceptions is the serial, exhaustive search model that Sternberg (1966, 1967, 1969) derived from choice reaction time studies of memory scanning. He asked subjects to memorize a short list of digits and then to respond "Yes" or "No" as to whether a test digit was a member of the memorized set. Sternberg hypothesized that four sequential stages intervene between the stimulus and response: stimulus encoding, serial comparison, binary decision, and response translation and organization. Sanders (1980) has recently proposed that all current data using this choice reaction time method can be reconciled if six serial stages are assumed, of which the first two are predominantly sensory and the last two are motor. These stages and an associated experimental manipulation are shown in table 1. This type of model seems to have particular relevance for speeded performance on tasks involving single simple stimuli.

**Selective Attention.** The assumption that incoming sensory information proceeds through a sequence of information-processing stages has also been a component of most models of selective attention, although the more recent models have increasingly emphasized flexibility in control of processing and rejected a strict, fixed sequence of stages. Selective attention models within contemporary cognitive psychology focus on the processes

**Table 1. Stages of processing and associated experimental manipulations as proposed by Sanders (1980) [1]**

| Stage | Typical associated manipulations |
|---|---|
| Preprocessing | Signal contrast |
| Feature extraction | Signal quality |
| Identification | Signal discriminability, word frequency |
| Response choice | S-R compatibility |
| Response programming | Response specificity |
| Motor adjustment | Instructed muscle tension |

[1] Adapted from Sanders (1980).

that operate when multiple stimuli are presented simultaneously.

Early models of selective attention debated whether the site of selection was early (Broadbent 1958) or late (Deutsch and Deutsch 1963; Norman 1968) in the information-processing stage sequence. A series of studies showed that early selection by a simple physical characteristic of a stimulus (e.g., ear to which it is presented) was highly efficient, but could not account for the intrusion of some stimuli from unattended channels that had high contextual or adaptive significance (Moray 1959; Treisman 1960, 1964).

Broadbent (1971; see also Broadbent 1982) altered his 1958 filter model and suggested that three types of selection operations and corresponding places in the information-processing system may lead to loss of information between the stimulus input and the output of a limited-capacity perceptual channel. First, "filtering" refers to the selection of certain stimuli possessing a single particular physical feature (e.g., sex of voice, location at a certain point in space); this process enhances, but does not totally control, entry of stimulus input into the limited-capacity channel. Second, "categorizing" occurs within the limited-capacity channel and refers to processing only those features of a stimulus that show it to be a member of a certain class and not a member of other possible classes. Initially, categorizing develops slowly, but it becomes more efficient for a given set of classes with practice. Third, "pigeonholing" refers to applying a bias to the categories produced during the limited-capacity stage such that a certain category output from the limited-capacity channel will be triggered by less perceptual evidence than is usually required. Because categories can be formed from complex configurations of stimulus features rather than only single physical features, pigeonholing can influence processing of classes of stimuli based on more complex discriminations than those affected by filtering. The 1971 version of Broadbent's model has been applied to cross-sectional studies of deficits in schizophrenic adults by Hemsley and Richardson (1980) and Schwartz (1982), who emphasize greater difficulty in pigeonholing than in filtering among actively symptomatic schizophrenic patients.

A somewhat different approach to selective attention was proposed by Neisser (1967), who postulated that two interactive types of processes, preattentive processes and focal attention, can account for the selective processing of sensory input. Preattentive processes segregate the sensory input in a global, holistic fashion very rapidly (mostly in a simultaneous or parallel fashion), followed by more detailed, slower analysis of segments of the stimulus field receiving focal attention. Instead of operating by accepting or rejecting stimulus input for conscious attention, selective perception in Neisser's view is the result of the varying degrees to which stimuli are processed. Stimuli that are in the segment of the field receiving more extensive analysis (focal attention) are more likely to reach awareness. The emphasis on interaction between a fast, global processing mode and a slower, fine-detail processing mode is common to several contemporary theories and deemphasizes the earlier view (e.g., Broadbent 1958; Deutsch and Deutsch 1963) that selective attention occurs at a fixed stage of information processing.

**Processing Capacity Models of Attention.** Difficulties in locating a structural bottleneck at a certain fixed point in an information-processing stage sequence that corresponds to a limitation imposed by selective attention (e.g., Moray 1959; Treisman 1960) have led some theorists to quite different conceptions of the nature of attention. In many current models of information processing, attention is conceived as a limited nonspecific capacity or resource that can be allocated to specific processing tasks. An increased role of simultaneous or parallel processing is incorporated into these models by postulating that certain processes demand little or no processing capacity for completion. Certain other processes demand considerable processing capacity and therefore limit simultaneous performance of other cognitive operations that also require processing capacity.

Kahneman (1973) developed one of the first information-processing

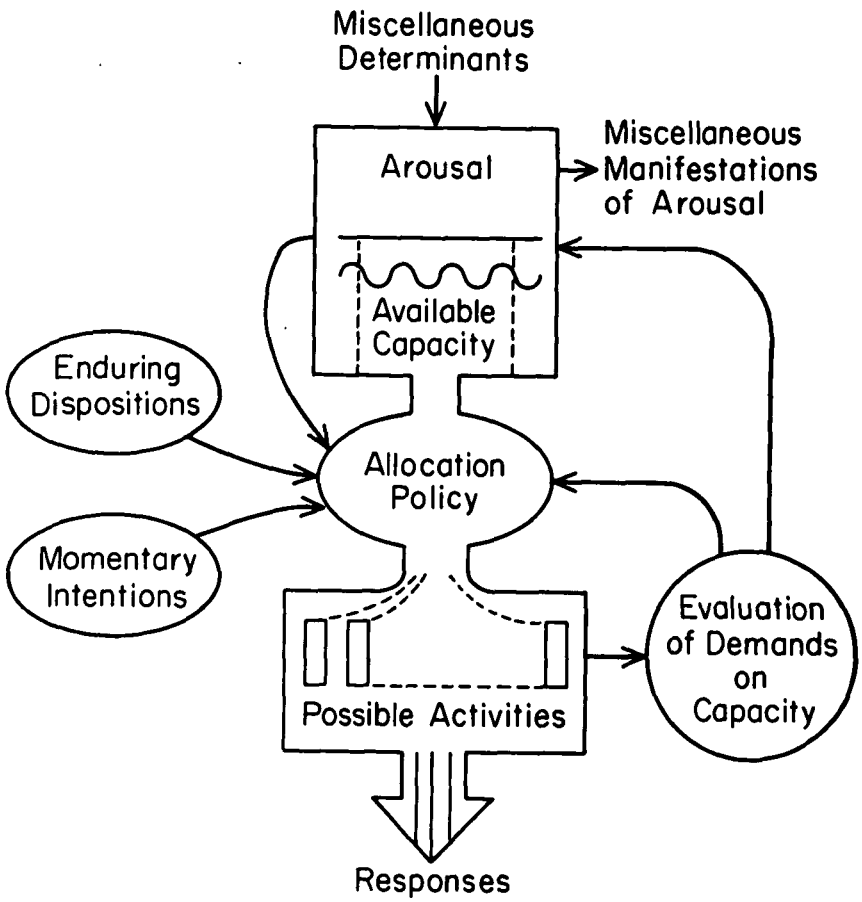
models based on this view of attention as processing capacity, as is summarized in figure 1. Instead of selective attention at certain stages of information processing, Kahneman (1973) emphasized the intensive dimension of attention and its connection to arousal. He argued that the individual has a certain amount of processing capacity available at a given moment. This amount is partially determined by current arousal level.

In Kahneman's (1973) model, the individual can allocate processing capacity to possible tasks fairly flexibly, devoting all of the processing capacity to one task or dividing it among several tasks. The allocation policy can be changed from moment to moment and may differ between individuals. Allocation policy is influenced both by enduring dispositions, which reflect rules of involuntary attention (e.g., allocate processing capacity to any novel stimulus), and by momentary intentions (e.g., select the message presented to the right ear). Arousal level can also vary from moment to moment and between individuals, thereby influencing the total amount of processing capacity. Finally, a feedback loop is hypothesized by which the individual's evaluation of the current task demands on capacity serves to adjust the level of arousal.

Acknowledging that the relationship between information processing and arousal may depend on certain components or indices of the arousal construct (cf. Vanderwolf and Robinson 1981), Kahneman (1973) emphasized sympathetic measures such as pupil diameter and skin conductance. He noted that the relationship between arousal and task performance follows the inverted U of the Yerkes-Dodson law, with the optimal level of arousal decreasing as tasks become more complex. In addition, he proposed that performance at low levels of arousal is impaired by failure to adopt a task set (a momentary intention) or failure to evaluate performance quality, thereby leading to an inappropriately low allocation of processing capacity. At overly high levels of arousal, Kahneman argued that performance is impaired, not by inadequate level of processing capacity, but by increased selection of the dominant stimulus features, difficulty in making fine discriminations between relevant and irrelevant stimulus features, and increased lability of the allocation policy for processing capacity. (Some information-processing correlates of electrodermal activity among schizophrenic patients are considered in the following article by Dawson and Nuechterlein, 1984).

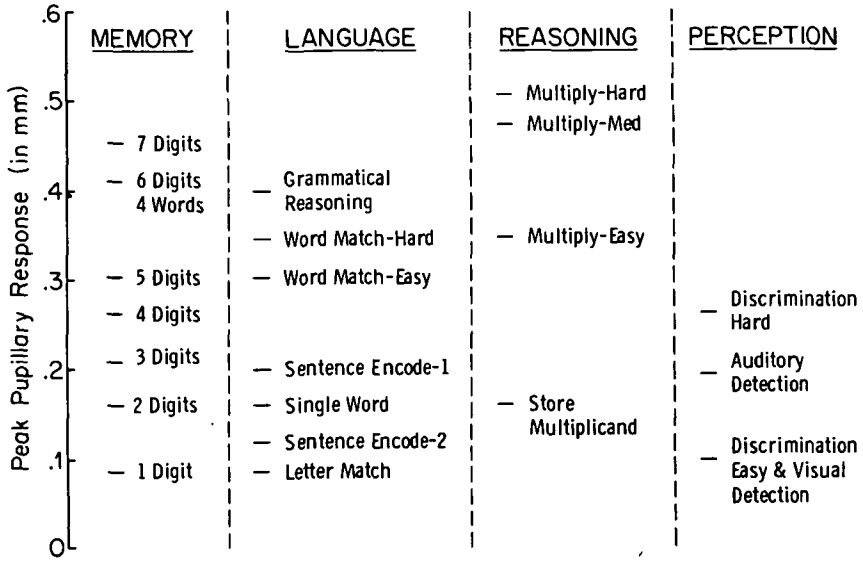
The shift from models of attention that propose structural bottlenecks at certain stages toward flexible allocation models that emphasize limits on the overall amount of processing capacity has major implications for studies of disordered processing of information. Processing deficits might reflect neither a specific

**Figure 1. Kahneman's (1973) capacity model for attention [1]**




[1] Reprinted with permission from: Kahneman, D. *Attention and Effort.* Englewood Cliffs, NJ: Prentice-Hall, Inc., 1973.

**Figure 2. Processing load of a range of cognitive tasks, as indexed by the peak amplitudes of the task-evoked pupillary responses [1]**




[1] From: Beatty, J. Task-evoked pupillary responses, processing load, and the structure of processing resources. *Psychological Bulletin*, 91:276-292, 1982. Copyright © 1982 by the American Psychological Association. Reprinted with permission.

dysfunctional stage in the information-processing chain nor a specific abnormal elementary cognitive operation, but rather decreased processing capacity, an abnormal allocation policy, or deviant level or regulation of arousal. According to Kahneman's model, a lowered level of processing capacity or abnormal levels of arousal would be expected to impair performance in a wide variety of tasks that demand processing capacity.

One important consideration derived from this view of information processing is that different aspects and types of tasks demand different amounts of processing capacity. Kahneman (1973) suggests that demands on processing capacity increase as cognitive operations move from early aspects of processing toward aspects near the response end. Task difficulty level also influences the amount of processing capacity demanded.

Evidence for such a scaling of the processing load of different tasks has recently been summarized by Beatty (1982*b*), who used the amplitude of the task-evoked pupillary response as a metric. Kahneman (1973) had suggested that task-evoked pupillary responses might provide a physiological measure of mental effort or processing load. Beatty notes that such momentary dilatations probably reflect "the cortical modulation of the reticular core during cognitive processing" (1982*b*, p. 290) and serve as an index of overall processing load similar to an electrical meter that measures the total amperage demanded at a given moment by the various electrical devices in a house. Summarizing the available evidence by use of this metric, Beatty (1982*b*) finds a meaningful progression of processing load both within and across cognitive task types (figure 2). Perceptual tasks involve relatively little processing load in comparison to moderately complex memory, language, and reasoning tasks, with visual and auditory detection and easy perceptual discriminations falling somewhat lower than difficult perceptual discrimination. Short-term memory tasks are highly varied in processing load, depending in a meaningful fashion on the number of items stored for recall. The processing load associated with language processing also varies widely from simple matching of two letters to sentence comprehension (grammatical reasoning). Among tasks for which pupillary response data are available, difficult quantitative reasoning tasks involve the greatest processing load. Thus, this evidence supports Kahneman's (1973) suggestion that mental operations near the stimulus end of information-processing sequences, such as simple visual detection, usually involve a lower processing load than higher-

level operations, such as sentence comprehension and short-term memory for six to seven digits. Furthermore, within tasks that demand similar types of cognitive operations (e.g., short-term memory), processing load can vary substantially, depending on task difficulty level. These relationships have important implications for the study of schizophrenic information processing, because if schizophrenic deficits involve restrictions on the overall level of available processing capacity, one would not expect performance deficits to be evident in tasks involving minimal processing loads (Knight and Russell 1978; Gjerde 1983; Nuechterlein, in press *b*). On the other hand, deficits may be present across many types of effortful mental operations if the processing load imposed is greater than the allocated processing capacity.

**Multistore Models of Episodic Memory.** Paralleling the movement of models of attention from notions of a structural bottleneck to those of limited processing capacity, models of human memory have shown a shift of emphasis from memory structures to memory processes during the course of their development in the last 20 years. The influential multistore model of Atkinson and Shiffrin (1968) postulated that three memory stores are the fundamental structural elements—the sensory register, the short-term store, and the long-term store. The sensory register retains sensory information in a preconscious, relatively complete form for a very brief period. This store dissipates rapidly over time and can be erased by new information arriving from the senses. Typical studies of the sensory register in the visual system (iconic storage) employ the partial-report span of apprehension task (Sperling 1960) or visual masking (Averbach and Coriell 1961). The partial-report span of apprehension procedure involves a very brief presentation of a visual stimulus array followed by a cue to report the stimuli in a certain part of the array. Visual masking procedures present two brief stimuli in rapid succession to determine the effect of one of the stimuli (the mask) on the perception of the other (the target). Analogous techniques have been used to study the auditory sensory register (echoic storage). The typical estimates of the duration of sensory storage are around 250 msec.

The short-term store in Atkinson and Shiffrin's (1968) model is an active, working memory in which information from the sensory store and the long-term store is processed by conscious memory routines (e.g., rehearsal). Information can be retained in the short-term store as long as constant attention is devoted to it, but disappears without attention after 15 to 30 seconds. The short-term store, in contrast to the sensory register, has quite limited storage space and therefore requires careful selection of information that is to be processed by conscious memory routines. Conscious manipulation of information occurs only in short-term, working memory, not in the sensory register or long-term store.

The long-term store in Atkinson and Shiffrin's (1968) model is a repository for an unlimited amount of information that flows from the short-term store and possibly also from the sensory register. Control processes in the short-term store facilitate transfer of information into the long-term store by relating its content to the content of long-term store.

**Automatic vs. Attention-Demanding Processing.** The recent increased emphasis in information-processing theory on memory processes, rather than memory structures, coincides with the development of a distinction between processes that draw on limited processing capacity (attention) and those that occur automatically without capacity limitations. This distinction has bridged many traditionally separate topics of attention and memory research. Distinctions between automatic and attention-demanding processes have been made by Posner (1978; Posner and Snyder 1975) in the context of letter matching and priming, by Shiffrin and Schneider (1977; Schneider and Shiffrin 1977) for a hybrid of visual search and memory search tasks, and by Hasher and Zacks (1979) for a variety of memory tasks.

Shiffrin and Schneider (1977; Schneider and Shiffrin 1977) propose the distinction between automatic and controlled (attention-demanding) processes within the general structure of a multistore memory model. Controlled processes are temporary sequences of mental operations that are under the control of the individual and that are activated by attention. These processes are capacity-limited because they involve active attention (processing capacity) and the limitations are those associated with short-term memory. Controlled processes are usually serial in nature, are relatively slow, and are subject to interference by other simultaneous controlled processing, but the sequence of mental operations can be flexibly adapted to the requirements of the situation. Serial comparison and rehearsal are examples of controlled processes.

According to Shiffrin and Schneider's theory, automatic

processing involves activation of a fixed sequence of mental operations that is a response to a particular input configuration and that occurs without the active control or attention of the individual. Automatic processes involve direct access to long-term memory, are not capacity-limited, and do not interfere with other simultaneous processing, but are difficult to suppress or modify. Shiffrin and Schneider emphasize the role played by extended practice with consistent stimulus-response combinations in their account of the development of automatic processing. The encoding of very familiar letter or number characters to the recognition level is one process that is usually automatic, but Schneider and Shiffrin also propose that rather complicated behavioral sequences, such as a braking response to a red traffic light, may become automatic with sufficient practice.

Posner (1978; Posner and Snyder 1975) makes a similar distinction between automatic processes and processes demanding conscious attention. Automatic processes are characterized by occurring without intention, without conscious awareness, and without interfering with other mental operations. Such processes occur in parallel by activating a "psychological pathway" that consists of the internal codes and connections associated with a well-learned stimulus. Automatic activation of such a pathway creates temporary facilitation of processing of a subsequent identical or similar stimulus without inhibition of unrelated stimuli.

In Posner's model, conscious attention is a limited-capacity system that can be flexibly and voluntarily directed to increase the efficiency of processing certain stimuli at various stages of information processing. The capacity limitations of conscious attention are evidenced through interference with performance during simultaneous tasks. Furthermore, conscious attention is allocated preferentially to expected events, resulting in facilitated performance if the expected event occurs. However, unlike automatic processing, the occurrence of an unexpected event that requires processing will result in impaired performance due to the time required to shift conscious attention away from the expected event and to the event that actually occurred.

Like Shiffrin and Schneider (1977), Posner (1978) posited that the encoding of a familiar letter stimulus was an automatic process that did not interfere with other processing. On the other hand, he noted that the serial comparison that is involved in determining whether an initial letter matches a second letter demands conscious attention. These conclusions were based on the absence of interference with performance on a secondary task caused by the initial appearance of the first letter and the subsequent secondary task interference around the arrival of the second letter stimulus. Subsequent research (Papp and Ogden 1981) has shown that letter encoding involves some processing capacity and is therefore not totally automatic, but the amount demanded remains small relative to that involved in serial comparisons.

The distinction between automatic and attention-demanding processes has been applied to a broad range of memory phenomena by Hasher and Zacks (1979), who use the term "effortful" to describe processes that involve demands on the limited-capacity system. Hasher and Zacks (1979) view automatic and effortful processes as opposite poles of a continuum rather than as a dichotomy. Furthermore, extending the views of Kahneman (1973), Hasher and Zacks emphasize that certain organismic and environmental states influence processing capacity and therefore also influence effortful processes, but automatic processes are normally impervious to variations in such states. High arousal level, old age, and depression are among the states that they hypothesize reduce processing capacity. According to the Hasher and Zacks model, high arousal level or other states that decrease processing capacity would be expected to impair effortful operations such as recall, rehearsal, and elaborative mnemonic activities. However, relatively automatic processes such as simple recognition, coding of temporal information about stimuli, and activation of word meaning should not be disrupted by reductions in processing capacity.

Some difficulties remain in the conception of automatic processes (Kahneman and Treisman, in press), but the differentiation of cognitive processes into relatively automatic and relatively effortful, controlled, attention-demanding operations does allow a meaningful examination of the differential impairment of these two groups of processes in psychopathological conditions. If the psychopathological condition involves a reduction in overall processing capacity or an inadequate allocation of processing capacity to task-relevant operations, impaired performance should be evident in tasks that demand effortful, controlled processes and absent in tasks involving automatic processes. Furthermore, impairment in effortful, attention-demanding processes may be related to symptomatic state or arousal state. Thus, the presence of such deficits should be examined in

several different states to determine whether they occur only when certain states reduce available processing capacity.

**Sustained Attention or Vigilance.** The topic of sustained, focused attention has been a prominent one in many clinical and experimental descriptions of schizophrenic performance impairment, particularly in the work of Shakow (1962, 1979) and Kornetsky, Mirsky, Orzack, and their colleagues (Kornetsky and Mirsky 1966; Orzack and Kornetsky 1966; Wohlberg and Kornetsky 1973; Kornetsky and Orzack 1978). Shakow maintained that the central cognitive dysfunction in schizophrenic disorders was an inability to maintain a major task set, which might be described as a dysfunction in sustaining the readiness to respond to task-relevant or signal stimuli over time. Shakow, Zahn, Cromwell, and Steffy have employed simple reaction time as a function of preparatory interval as the primary task paradigm in examinations of this and related hypotheses (Zahn, Rosenthal, and Shakow 1961, 1963; Cromwell et al. 1961; Steffy and Galbraith 1974; Steffy 1978; see Nuechterlein 1977*a*, 1976*b* for an analysis). Kornetsky, Mirsky, Orzack, and their colleagues have, on the other hand, used the continuous performance test (CPT), a visual vigilance task, as their principal experimental measure of sustained attentional deficit in schizophrenia. The CPT involves monitoring a quasi-random series of stimuli (usually single numbers or letters) as they are presented briefly one at a time in a continuous sequence at about one per second and pressing a response button each time that a predesignated stimulus occurs (Rosvold et al. 1956). These lines of research into schizophrenic deficits have remained relatively separate from recent research on sustained attention within normal subjects. Recent developments in the experimental psychology of vigilance offer an improved understanding of underlying processes that may shed light on schizophrenic impairment.

In the literature on CPT performance in various psychopathological groups, the traditional indices of sustained attention have been (1) errors of commission or target misses and (2) errors of commission or responses to nontargets (e.g., Orzack and Kornetsky 1966; Kornetsky 1972; Sykes, Douglas, and Morgenstern 1973; Asarnow and MacCrimmon 1978; Klorman et al. 1979). Analyses of vigilance performance in normal subjects have increasingly employed the signal detection theory distinction between sensitivity and response criterion dimensions to discriminate two processes within vigilance performance (Mackworth 1970; Davies and Parasuraman 1982). These two independent performance indices are derived from the traditional indices of errors of omission and errors of commission, and summarize performance through joint consideration of the error tendencies represented by these two traditional indices. Sensitivity refers to the subject's level of discriminating target (signal) stimuli from nontarget (noise) stimuli. High sensitivity usually corresponds to a relatively high target hit rate (few errors of omission) and a relatively low false alarm rate (few errors of commission). Response criterion refers to the amount of perceptual evidence that the subject requires in order to decide that a stimulus is a target. A subject adopting a high, "cautious" response criterion shows a lower hit rate but also a lower false alarm rate than he would if he adopted a moderate response criterion, whereas use of a low, "liberal" response criterion leads to a relatively higher hit rate but also a higher false alarm rate.

Although most vigilance tasks yield a drop in the target hit rate over time, only some produce a decrement in sensitivity. A decrement in sensitivity over time can be considered strong evidence of decreased sustained attention, whereas hit rate decrements that can be accounted for by increased response criterion indicate no change in the subject's capacity to discriminate target and nontarget stimuli (Davies and Parasuraman 1982). Recent research indicates that vigilance-task conditions produce sensitivity decrements over time in normal subjects only when the stimulus presentation rate is high and the targets involve (1) memory for successive stimuli (Parasuraman 1979) or (2) highly degraded stimuli (Nuechterlein, Parasuraman, and Qiyuan 1983). Nuechterlein, Parasuraman, and Qiyuan (1983) suggest that vigilance tasks that involve detection of single, highly familiar, clearly focused target stimuli entail a process of encoding to a recognition level that occurs automatically or at least with very limited demands on processing capacity (Shiffrin and Schneider 1977; Posner 1978). On the other hand, Nuechterlein, Parasuraman, and Qiyuan (1983) suggest that vigilance tasks that produce a decrement in sensitivity over time (sustained attention) involve greater demands on processing capacity due to the need to process sequentially either (1) successive stimulus presentations or (2) the multiple ambiguous features of individual highly degraded stimuli. Thus, the decrement in sustained attention may be linked to the momentary processing load imposed by the

various types of vigilance tasks.

Additional evidence that sustained attention decrements may be connected to processing load and task-evoked activation has recently been presented by Beatty (1982a), using phasic task-evoked pupillary dilations to vigilance-task stimuli as an index of momentary "mental effort" or intensity of attention in a sample of normal subjects. Beatty found that changes in sensitivity over time were highly correlated (median $r = .94$) with changes in phasic pupillary dilations for subjects who showed sensitivity decrements. Thus, these results suggest that decrements in sustained attention are related to changes in the intensity of attention that is evoked by or allocated to vigilance-task stimuli. Furthermore, they suggest that the processes of intensive and sustained attention may share a common neurophysiological basis that might help to relate vigilance performance to other tasks involving varying loads on processing capacity.

## Studies of High-Risk Populations

Among studies of the antecedents of schizophrenic disorder that have examined attentional and information-processing variables, at least three different sample selection procedures can be delineated. The first involves the examination of first-degree relatives of schizophrenic patients, usually the offspring. Compared to a general population risk of 1 percent or less, the risk of schizophrenia based on genetic relationship to a schizophrenic index case is about 12–14 percent for children, about 8–10 percent for siblings, and about 4–6 percent for parents (Gottesman 1978). The second approach has been to select individuals who show personality characteristics that are believed to be related to an increased risk for schizophrenic disorder (Steronko and Woods 1978; Chapman, Edell, and Chapman 1980). A third strategy has been to select subjects who have biochemical characteristics that have been observed among schizophrenic patients, an approach that has been applied to attentional variables by Buchsbaum et al. (1978).

Studies of these three types of high-risk populations will be reviewed together to facilitate a comparison of findings. Before examining studies that have used laboratory performance measures of information processing, we want to note the contribution of clinical and parental observations. In the earliest longitudinal study of children of schizophrenic mothers, Barbara Fish (1963, 1975, 1977; Fish and Alpert 1962, 1963) had noted aspects of the development of attention, arousal, and muscle tone in some infants that appeared abnormal. A pattern with possible relevance to attention and arousal involved an abnormally quiet state, including underactivity, hypotonia, and lack of crying already present during the first 4 weeks of life, that was associated with severe psychopathology at 10 years of age and Fish's diagnosis of severe schizophrenia spectrum disorder at 20 to 22 years of age in three of four cases (Fish 1975, 1977, 1982). Fish (1982) notes that this abnormally quiet state in infancy seemed to be related to the later negative symptom of affective blunting.

Parnas et al. (1982) have also reported observational data from the large sample of 173 children of schizophrenic mothers who were assessed in 1972–74 as part of a 10-year followup within the Danish longitudinal high-risk study begun by Mednick and Schulsinger in 1962 (Mednick and Schulsinger 1968). Outcome clinical diagnoses of schizophrenia and schizophrenia spectrum disorder within this sample were significantly related to earlier parental reports that children were passive babies and showed poor concentration during play with familiar toys as babies. An adjective checklist scale of "formal cognitive disturbance" based on a psychiatric interview at a mean age of 15.1 years also significantly predicted 10-year outcome diagnoses of schizophrenia, borderline schizophrenia, and schizophrenia spectrum disorder. This formal cognitive disturbance scale was heavily loaded with adjectives referring to attentional functioning, consisting of the descriptors (English translation): unconcentrated, confused, absentminded, inattentive or distractible, and preoccupied. Adolescents with a schizophrenia spectrum outcome scored high on this formal cognitive disturbance scale in 55 percent of cases (23 of 42), whereas only 16 percent of adolescents (9 of 55) with no mental illness 10 years later scored high. Thus, observational data support the hypothesis that deviations in the general domain of focused attention, concentration, and alertness do precede clinical conditions in the schizophrenia spectrum in a substantial number of cases.

A number of studies have now used laboratory performance tasks in an attempt to measure possible vulnerability indicators in this domain more objectively and to determine the nature of the deficit. Although it is impossible to categorize precisely the predominant processes involved in these tasks because each task entails multiple aspects of information processing, table 2 presents a rough grouping of the studies, tasks, and prominent processes for organizational purposes.

**Table 2. Studies of information processing and attentional functioning in risk populations**

| Predominant process | Task | Relevant references |
|---|---|---|
| Maintaining readiness to respond over time | Simple reaction time (RT), with varying preparatory interval or modality | Marcus (1973)<br>Van Dyke, Rosenthal, & Rasmussen (1975)<br>Asarnow et al. (1977)<br>DeAmicis & Cromwell (1979)<br>Spring (1980)<br>Simons, MacMillan, & Ireland (1982)<br>Phipps-Yonas (in press) |
| | Choice RT (overall level) | Wood & Cook (1979) |
| Sustaining focused attention over time | Continuous performance test (CPT) with single focused target | Grunebaum et al. (1974)<br>Asarnow et al. (1977)<br>Cohler et al. (1977)<br>Herman et al. (1977)<br>Grunebaum et al. (1978)<br>Nuechterlein (1983)<br>Cornblatt & Erlenmeyer-Kimling (in press) |
| | CPT with single, degraded target | Nuechterlein et al. (1982)<br>Nuechterlein (1983)<br>Nuechterlein, Asarnow, & Marder (in preparation)<br>Nuechterlein, Edell, & West (in preparation) |
| | CPT with sequential target | Rutschmann, Cornblatt, & Erlenmeyer-Kimling (1977)<br>Buchsbaum et al. (1978)<br>Erlenmeyer-Kimling & Cornblatt (1978)<br>Nuechterlein (1983)<br>Cornblatt & Erlenmeyer-Kimling (in press)<br>Erlenmeyer-Kimling et al. (in press *a*) |
| | Other vigilance task with sequential target | Wood & Cook (1979) |
| Simple auditory detection | Signal detection task | Orvaschel et al. (1979) |

**Table 2. Studies of information processing and attentional functioning in risk populations—*Continued***

| Predominant process | Task | Relevant references |
|---|---|---|
| Selective attention with immediate response | Dichotic listening | Asarnow et al. (1977)<br>Orvaschel et al. (1979)<br>Spring et al. (1983) |
| | Information overload test | Cornblatt & Erlenmeyer-Kimling (in press) |
| | Embedded figures test | Grunebaum et al. (1974)<br>Gamer et al. (1977)<br>Cohler et al. (1977)<br>Grunebaum et al. (1978) |
| | Stroop Color-Word Test | Asarnow et al. (1977) |
| | Spokes Test (also sustained, focused attention) | Asarnow et al. (1977) |
| | Visual search | Winters et al. (1981) |
| Sensory storage and read out | Visual masking | Steronko & Woods (1978)<br>Braff (1981)<br>Saccuzzo & Schubert (1981) |
| | Forced-choice span of apprehension | Asarnow et al. (1977)<br>Asarnow, Nuechterlein, & Marder (1983) |
| Short-term recognition memory | Short-term memory lag | Rutschmann, Cornblatt, & Erlenmeyer-Kimling (1980)<br>Erlenmeyer-Kimling et al. (in press *b*) |
| | Memory for dot numerousness | Koh & Peterson (1974) |
| | Intentional and incidental learning tasks | Driscoll (in press) |
| Short-term recall memory | Attention-span task | Erlenmeyer-Kimling & Cornblatt (1978) |
| | Visual-aural digit span | Cornblatt & Erlenmeyer-Kimling (in press) |
| | Digit-span distractibility task | Winters et al. (1981)<br>Harvey et al. (1981)<br>Neale (1982) |

**Table 2. Studies of information processing and attentional functioning in risk populations—*Continued***

| Predominant process | Task | Relevant references |
|---|---|---|
| | Intentional and incidental learning tasks | Driscoll (in press) |
| Concept formation | Concept attainment task | Asarnow et al. (1977) |
| | Object sorting test | Oltmanns et al. (1978)<br>Winters et al. (1981)<br>Neale (1982) |
| Semantic memory and word production | Word association | Mednick & Schulsinger (1968)<br>Griffith et al. (1980) |
| | Referential communication | Winters et al. (1981)<br>Martin & Chapman (1982) |

**Maintaining Readiness to Respond Over Time.** Several studies have used simple reaction time (RT) paradigms with either varying preparatory intervals or varying stimulus modalities over trials. Subjects are asked to respond with a button press or lift as quickly as possible when a simple suprathreshold auditory or visual stimulus appears. These paradigms apparently tap several different processes among schizophrenic patients (Nuechterlein 1977*a*, 1977*b*; Spring and Zubin 1977; Mannuzza 1980), but all involve at least the ability to maintain an optimal level of readiness over time for rapid processing of simple sensory stimuli and for rapid motor responding.

Marcus (1973; see Garmezy 1978) applied a simple RT paradigm with varying preparatory intervals, which had been used extensively by Shakow and his colleagues (Shakow 1962) with adult schizophrenic patients, to 20 children of schizophrenic mothers and multiple comparison groups. These children of schizophrenic mothers in school grades four through eight showed a significantly slowed overall level of RT as compared to normal comparison children, paralleling the characteristic slow RT of schizophrenic patients (Huston, Shakow, and Riggs 1937; Rodnick and Shakow 1940). However, they did not show the characteristic pattern of RT crossover that distinguishes process schizophrenic performance, as shown in figure 3, in which RT to predictable preparatory intervals rapidly becomes slower than RT to unpredictable preparatory intervals as the intervals get longer (Rodnick and Shakow 1940; Steffy and Galbraith 1974). Marcus (1973) did find that children of schizophrenic mothers continued to show slow overall RT in comparison to normal control children even under conditions in which material incentives were offered and children were allowed to choose preparatory intervals before each trial, suggesting that the relative deficit was quite stable and not motivationally based.

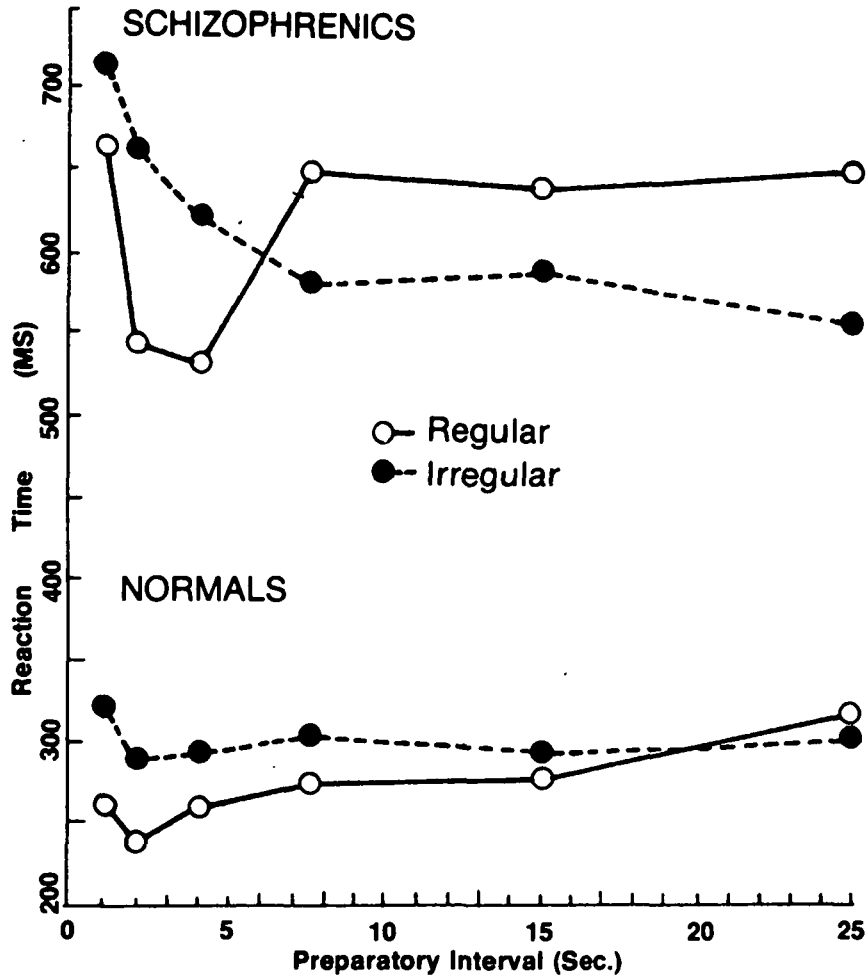
The results of four other studies of simple RT in offspring and siblings of schizophrenic patients suggest that overall simple RT slowing to simple sensory stimuli is not a robust indicator of vulnerability to schizophrenic disorder. Asarnow et al. (1977, 1978) found that overall RT was somewhat but not significantly slower among foster-reared adolescents born to schizophrenic mothers than among foster-reared or biological-parent-reared adolescent comparison groups. Although the absolute amount of overall slowing was similar to that of the Marcus (1973) high-risk sample (about 30), the smaller sample size ($n = 9$) and larger score variance in the Asarnow et al. high-risk sample may have contributed to lack of statistical significance. However, overall RT also failed to differentiate significantly 22 offspring of schizophrenic mothers from normal comparison children within a cross-modal RT paradigm that used brief preparatory intervals (Nuechterlein et al. 1982; Phipps-Yonas, in press). Spring (1980) similarly found that overall simple RT did not discriminate siblings of schizophrenic patients

from normal subjects in a cross-modal RT paradigm. The latter studies were also congruent in finding that slowing associated with switching the sensory modality of the imperative stimulus in sequential trials was not greater than normal in persons at risk for schizophrenia, despite the fact that such cross-modal retardation does characterize the active schizophrenic state.

Finally, results of a cross-fostering study by Van Dyke, Rosenthal, and Rasmussen (1975) suggest that overall simple RT slowing may be associated in some cases with rearing by a schizophrenic parent. Adults who had been reared by a schizophrenic parent were significantly slowed in overall RT regardless of whether a biological parent had schizophrenia, whereas adults with a biological parent with schizophrenia did not differ in RT from adults without such a genetic history. Neither the genetic nor the rearing relationship to a schizophrenic parent was associated with the RT crossover pattern. Van Dyke, Rosenthal, and Rasmussen suggest that slowed overall responses may have resulted from preoccupation with family problems and reduced spontaneity associated with rearing by a schizophrenic parent.

Positive RT crossover results among risk populations have recently been reported in two studies that used a procedure developed by Steffy in which each series of regular (predictable) preparatory interval trials is embedded in a longer irregular (unpredictable) series (Bellissimo and Steffy 1972; Steffy and Galbraith 1974). DeAmicis and Cromwell (1979) selected process schizophrenic patients who exhibited the characteristic RT crossover pattern and examined their first-degree relatives. They found a significant excess of nonpsychotic relatives with the RT crossover pattern as compared to normal control subjects when a strong form of the crossover was evaluated. Furthermore, the magnitude of crossover in the schizophrenic group was positively correlated with the number of first- and second-degree relatives who had been hospitalized.

**Figure 3. Reaction times of schizophrenic and normal subjects [1]**




*Note.*—Mean reaction times are shown of 25 schizophrenic and 10 normal subjects at the various preparatory intervals of the regular and irregular warning procedures.

[1] Reprinted with permission from: Rodnick, E., and Shakow, D. Set in the schizophrenic as measured by a composite reaction time index. *American Journal of Psychiatry*, 97:214-225, 1940.

Simons, MacMillan, and Ireland (1982) selected undergraduates who scored high on a Perceptual Aberration Scale or a Physical Anhedonia Scale, two questionnaire measures of hypothesized psychosis-proneness developed by Chapman, Chapman, and Raulin (1976, 1978). These scales identify subjects who show schizo-

phrenic-like thinking in their Rorschach responses (Edell and Chapman 1979) and a heightened number of schizotypal features in a structured psychiatric interview (Chapman, Edell, and Chapman, 1980). Simons, MacMillan, and Ireland (1982) found that mean analyses of both the Perceptual Aberration and the Physical Anhedonia groups showed evidence of the crossover pattern relative to a group without elevation on the psychosis-proneness scales. Individual analyses of the RT patterns demonstrated that the Perceptual Aberration group also included a disproportionate number of subjects who showed a strong form of the crossover pattern.

Finally, Wood and Cook (1979) found that siblings of schizophrenic patients showed significantly slowed overall RT in a 10-choice visual RT paradigm. Choice RT involves a substantial decision time component in addition to preparatory readiness and motor speed. Thus, it is unclear whether this slowing is due to the same processes as that in the simple RT studies.

In summary, the results of RT studies with populations at known or hypothesized increased risk of schizophrenia are somewhat inconsistent. Increased overall simple RT has sometimes been demonstrated in the Shakow paradigm in which separate, relatively long blocks of regular (predictable) and irregular (unpredictable) preparatory intervals are administered, but the typical schizophrenic crossover pattern has not been present. Two studies that used Steffy's embedded set paradigm, however, have demonstrated RT crossover patterns in genetically defined and questionnaire-defined high-risk samples. Direct comparison of the Shakow and Steffy paradigms on the same subjects might help to clarify these results, as it appears that the presence of a few predictable preparatory intervals within a series of unpredictable intervals in Steffy's procedure may lead to more striking crossover effects (Bellissimo and Steffy 1972) than in the Shakow procedure and may contribute to the positive results with this paradigm. Perhaps the greater complexity of the temporal sequencing of preparatory intervals in the Steffy procedure is a contributing factor.

The inability of the high-risk subjects to take advantage of the predictability of the imperative stimulus at longer preparatory intervals suggests a deficit in maintaining conscious, capacity-loading attention, because it is under conditions of stimulus predictability that Posner (1978, 1982) has argued that conscious attention should benefit performance by facilitating rapid processing of the expected stimulus. Inability to profit from predictability is not the total explanation, however, because the crossover phenomenon involves, not just equal RT, but actually slower RT under predictable as compared to unpredictable long preparatory intervals.

**Sustaining Focused Attention Over Time.** The processing demands of tasks reviewed in this section differ from those in the previous section by being more continuous over time and by involving selection of certain signal stimuli for immediate response from a sequence of signal and noise stimuli. Vigilance tasks, particularly versions of the Continuous Performance Test (CPT), are the primary examples. The finding of deficits in vigilance performance among populations at risk for schizophrenia appears to depend at least partially on the processing load of the task, so we will review the findings in the order of increasing estimated processing load.

Asarnow et al. (1978) administered a version of the CPT that required adolescents to press a response key every time that the digit 7 appeared in a random sequence of single digits that were presented for 80 msec each with a 1.1-second interstimulus interval. Offspring of schizophrenic mothers were not significantly differentiated from nonpsychiatric comparison adolescents. Nuechterlein (1983) used a similar version as one of six CPT conditions and also found that 9- to 16-year-old children of schizophrenic mothers could not be significantly discriminated from normal comparison children. The task involved detection of a clearly focused single target digit presented even more briefly (40 or 50 msec, depending on the child's age) but at a somewhat slower rate (1.4-second interstimulus interval). Erlenmeyer-Kimling and Cornblatt (Cornblatt and Erlenmeyer-Kimling, in press; Erlenmeyer-Kimling et al., in press *b*) used another CPT version with a clearly focused target stimulus (08) that did not involve memory of the previous stimulus and also failed to find differences between children of a schizophrenic parent and children of normal parents in separate samples of 7- to 12-year-olds and 13- to 18-year-olds.

A study reported by Grunebaum et al. (1974) and Gallant (1972) suggests that even a CPT version with a relatively simple target stimulus might detect a vigilance deficit among very young children of schizophrenic mothers, possibly because this task nevertheless involves a substantial sustained processing load at an early age. Using the color red as the target stimulus in a series of color stimuli, they found that 5-year-old children of schizophrenic mothers detected fewer targets than children of affectively disordered mothers or children of nonpsychiatric parents and tended

to make more incorrect presses (false alarms) than children of nonpsychiatric parents. These differences were not present, however, in 6-year-old children, for whom a single letter target (X) was used. Because the two groups differ in stimulus type, diagnostic group sample size, chronicity of maternal psychiatric disorder, and age, the critical dimension determining these discrepant findings is not clear. A later project report by Cohler et al. (1977), using a sample with a few deletions and additions, notes failure to find any group differences in CPT performance. However, these analyses combine data from 5- and 6-year-old children, despite the fact that the CPT version used for 5-year-olds led to more errors for all groups and may thereby tap subtle deficits in the 5-year-old children of schizophrenic mothers more sensitively due to its higher processing load.

Herman et al. (1977) and Grunebaum et al. (1978) report followup data from this same high-risk project for examination of children 6 to 12 years old. They failed to find significant differences between children of schizophrenic mothers and children of normal mothers in performance on a CPT version with a clearly focused, single letter target, which is consistent with other findings involving such a version with this age group.

In contrast to these predominantly negative findings, results from CPT versions that involve a greater processing load have been quite positive. Erlenmeyer-Kimling and Cornblatt (1978) used playing card slides as stimuli and asked 7- to 12-year-old children to respond each time that two identical stimuli appeared in sequence. The memory load in this task is substantial, because the subject must process successive stimuli along two dimensions (number and suit) and use a relative rather than an absolute target criterion under time pressure (1.4-second interstimulus interval). Children of schizophrenic mothers obtained fewer target hits, more false alarms to clearly irrelevant stimuli, and lower sensitivity (d') or signal-noise discrimination than children of parents without psychiatric disorder (Rutschmann, Cornblatt, and Erlenmeyer-Kimling 1977; Erlenmeyer-Kimling and Cornblatt 1978). The high-risk children did not show abnormal response criterion levels, which indicates that cautious responding was not the source of the deficit.

Nuechterlein (1983, in press *c*) used the playing-card CPT, as well as new CPT adaptations with a single digit target stimulus that involved perceptual degradation of stimuli or reversal of the response requirements. As noted in the previous section that reviewed information-processing concepts, stimulus degradation burdens stimulus encoding and feature extraction aspects of information processing, whereas response reversal burdens response selection aspects (Sternberg 1967, 1969; Sanders 1980). Principal-components analysis of signal detection theory indices showed that five conditions of the CPT with such increased processing requirements, including the playing-card CPT, loaded on two performance factors, one reflecting the sensitivity (d') indices from each condition, which measure signal-noise discrimination, and the other, the response criterion indices. Nine- to 16-year-old children of schizophrenic mothers showed lower mean scores on the sensitivity factor and included more extremely poor scorers than normal comparison children. Again, response criterion levels were not altered in the high-risk children. The degraded-stimulus CPT considered alone also achieved significant differentiation of children of schizophrenic mothers and normal comparison children and was the most effective condition for isolating a disproportionately large group of high-risk children with poor signal-noise discrimination (low sensitivity). The fact that the degraded-stimulus CPT version, in contrast to the playing-card CPT, does not involve a target that demands memory for successive stimuli suggests that processing load, rather than memory load per se, might be important in the detection of vigilance performance deficits in children at high risk for schizophrenia.

Data from two other samples at genetic risk for schizophrenia are consistent with these positive findings for vigilance tasks with increased processing load. In a second sample of 7- to 12-year old children of a schizophrenic parent, Cornblatt and Erlenmeyer-Kimling (in press) found lower sensitivity (d') and fewer target hits than in children of normal parents for a CPT version in which the target was a succession of two identical double-digit stimulus trials in a row. Similarly, Wood and Cook (1979) showed that siblings of schizophrenic patients detected fewer targets in an auditory vigilance task in which the target was three consecutive odd digits within a series of digits read at the rate of one per every 0.8 second.

Two other studies have recently shown that low sensitivity level (poor signal-noise discrimination) during vigilance also characterizes persons hypothesized to be at increased risk for schizophrenia by virtue of schizotypal characteristics. Nuechterlein, Edell, and West (in preparation) selected college students who had 2-7-8 profiles on the Minnesota Multiphasic Personality Inventory (MMPI), a combination of

elevated scales that has been associated with schizotypal features (Marks, Seeman, and Haller 1974; Kelley and King 1979; Edell, submitted for publication) and later schizophrenic diagnoses (Peterson 1954) as well as possibly affective psychoses (Haier et al. 1979; Winters, Weintraub, and Neale 1981). In comparison to a group of subjects with no elevated scales and a group with elevations on scales other than scale 8 (Schizophrenia), the 2-7-8 subjects were found to detect fewer target stimuli and to have lower sensitivity on an adult version of the degraded-stimulus CPT that again used a single digit target that was difficult to discriminate from nontarget digits. Furthermore, in a study of young adults from temporary employment agencies who had no history of psychiatric disorder, Nuechterlein, Asarnow, and Marder (in preparation) found that subjects showing low sensitivity on this degraded-stimulus CPT had significantly higher scores on the MMPI Schizophrenia scale, the Physical Anhedonia scale (Chapman, Chapman, and Raulin 1976), the Schizoidia scale (Golden and Meehl 1979), and the Schizophrenism scale (Nielsen and Peterson 1976) than the remainder of the subjects.

One study (Buchsbaum et al. 1978) has indicated that individuals who have biochemical characteristics which have been postulated to be associated with schizophrenic symptomatology show deficits on a CPT version that uses a sequence of single digits in two consecutive trials (4-6) as the target stimulus. Subjects from a college population who had low monoamine oxidase (MAO) and dopamine-$\beta$-hydroxylase (DBH) levels made more errors of commission (false alarms) than subjects with low MAO and high DBH. As Buchsbaum et al. (1978) note, low MAO and low DBH have been associated with a number of psychotic conditions and the source of these biochemical anomalies is unclear, but the study provides an interesting alternative to other approaches to studying attentional functioning in known or hypothesized high-risk populations.

Because only a subgroup of each of these samples at risk for schizophrenia is actually expected to develop schizophrenic disorder, an important remaining question is whether these deficits in sustaining focused attention are predictive of the later developmental course. Erlenmeyer-Kimling et al. (in press *a*) have now identified 15 clinically deviant offspring of schizophrenic parents, five of whom have been hospitalized, out of 80 children of one or two schizophrenic parents who were followed up at a mean age of 17.5 years. Of the hospitalized subjects, three have diagnoses of schizophrenia, one schizoaffective, and one atypical premorbid schizophrenia with organicity by Research Diagnostic Criteria. The playing-card CPT performance at age 7 to 12 years was found to fall below the fifth percentile of the normal comparison group for all five of the hospitalized subjects and for 7 of 10 remaining clinically deviant offspring of schizophrenic parents (Erlenmeyer-Kimling et al., in press *a*). Furthermore, this clinically deviant group had a lower d′ (sensitivity) on the playing-card CPT from the initial testing and on the sequential-identical-digit CPT from the third round of testing than the remainder of the children of schizophrenic parents (Erlenmeyer-Kimling et al., in press *b*). Thus, early followup data from this project do strongly support the clinical predictive value of measures of sustained focused attention within a high-risk sample.

In summary, poor target hit rates and poor sensitivity (low signal-noise discrimination) during vigilance tasks that have relatively high processing load requirements have consistently been found to characterize children and siblings of schizophrenic patients as well as persons without schizophrenia who have some schizotypal features based on personality questionnaire data. Followup data on a sample of children of schizophrenic parents suggest that this poor sensitivity is an antecedent of schizophrenia and other early clinical deviance. Performance on vigilance tasks with lower processing loads generally does not significantly differentiate groups at known or hypothesized heightened risk for schizophrenia from comparison groups. Thus, the types of vigilance tasks producing performance deficits in groups at risk for schizophrenia seem at this point to be those that we noted earlier have been found to yield significant sensitivity deficits over time among normal individuals (Parasuraman 1979; Davies and Parasuraman 1982; Nuechterlein, Parasuraman, and Qiyuan 1983). Nuechterlein, Parasuraman, and Qiyuan (1983) have suggested that these vigilance tasks demand high levels of effortful, capacity-loading processing through the combination of fast event rates and targets that either require memory for successive stimuli (Parasuraman 1979) or serial processing of multiple features of a very ambiguous single target stimulus (Nuechterlein, Parasuraman, and Qiyuan 1983). Although most studies of groups at risk for schizophrenia have not examined differential sensitivity drops over time, Nuechterlein (1983) found that children of schizophrenic mothers were characterized primarily by a lowered overall level of sensitivity throughout the task, with only a trend approaching statis-

tical significance for target hit rate to decrease faster than normal over time. Because lower overall sensitivity level rather than differential sensitivity deficit over time has been the most distinctive feature among groups at risk for schizophrenic disorder, it is not clear whether the deficit that might index vulnerability to schizophrenic disorder is best characterized as one of sustained attention decrement per se. The deficit seems to be sensitively detected by vigilance tasks with relatively high processing loads, but it is possible that the essential problem involves a difficulty with the high moment-to-moment demands for processing capacity rather than the need to sustain efficient processing over a period of several minutes.

**Simple Auditory Detection.** The results of an auditory signal detection task using discrete trials are consistent with the possible role of processing load in deficits among persons at risk for schizophrenia. Orvaschel et al. (1979) report that sensitivity in a simple auditory detection task did not significantly discriminate children with a schizophrenic parent from children with normal parents. The detection of simple auditory stimuli in discrete trials would not involve the high processing load that is present in rapidly paced vigilance tasks, because stimuli were uncomplicated and could be processed without time pressure.

**Selective Attention With Immediate Response.** Several tasks that have been employed with populations at risk for schizophrenia involve simultaneous presentation of several different sets of stimuli with instructions to select one set for a relatively immediate response. Consistent with Broadbent's (1971) distinction between filtering and pigeonholing processes, we first review tasks that allow discrimination of the relevant stimulus set by a single physical cue and then tasks that demand more complex discriminations.

Dichotic listening tasks have been the most prominent measures of selective attention with immediate response in studies of populations at risk for schizophrenia. Asarnow et al. (1977, 1978) included a Competing Voices task in their battery that required subjects to write down a series of random digits that were presented to both ears while ignoring series of random digits that were presented to only one ear. Children of schizophrenic mothers as a group showed a marginally significant tendency to make more errors than children of nonpsychiatric parents in a condition with six irrelevant monaural voices. A subgroup including four of the nine high-risk children that was formed by cluster analysis of performance scores showed impaired performance in conditions with the highest numbers of irrelevant voices (6 and 12). Orvaschel et al. (1979) did not find significant impairment on a dichotic listening task in their children of schizophrenic mothers compared to children of normal parents, but they used stimulus strings of only three digits and did not require that the subjects select one message while ignoring another, so their task cannot be considered a clear test of selective attention.

Spring et al. (1983) have recently presented the strongest data for a dichotic listening deficit among first-degree relatives of schizophrenic patients, using a task version that required subjects to shadow (repeat) word strings presented to one ear while another word string was presented to the other ear. By analyzing at a phoneme level rather than at word level, Spring et al. (1983) were able to show that more intrusions of the irrelevant message occurred in first-degree relatives of schizophrenic patients than in normal comparison subjects. Thus, parents and siblings of schizophrenic patients had a subtle deficit in selective attention under conditions in which a single physical cue (ear of presentation) should allow selection by filtering.

Among the tasks that would likely demand a more complex discrimination is an Information Overload Test used by Cornblatt and Erlenmeyer-Kimling (in press), which requires subjects to choose one of four pictures that matches a target word that is presented binaurally under differing binaural distraction conditions. In comparison to children of normal parents, children of schizophrenic parents from 13 to 18 years old showed poorer recognition performance for the target word under conditions of distraction whether the distraction consisted of irrelevant school cafeteria sounds or a voice telling a story that subjects were required to remember. The first condition would again suggest a deficit in selective attention in the presence of simultaneous distraction in persons at risk for schizophrenia. A possible additional deficit in dividing attention between two relevant messages is suggested by the second condition, because recall for the story content was also deficient.

Several tasks involving complex visual discrimination among multiple simultaneous stimuli that are continuously present have also been examined with children of schizophrenic mothers. Gallant (1972), Grunebaum et al. (1974), and Gamer et al. (1977) reported that 3-year-old and 5-year-old children of psychotic mothers, in comparison to children of nonpsychiatric mothers, showed deficits on versions of the Embedded

Figures Test (Witkin et al. 1962), a task that involves selecting a simpler shape from a complex, embedding background. However, 6-year-olds did not show significant deficits (Grunebaum et al. 1974), and Cohler et al. (1977) reported that a reanalysis of the data with a slightly altered sample and covarying for verbal intelligence indicated that only the children of psychotically depressed mothers, not children of schizophrenic mothers, showed more failures to respond. These results are difficult to interpret due to small sample sizes, an ambiguous rationale for covarying verbal intelligence, and the presence of the disturbed mother in the room during testing. Grunebaum et al. (1978) report that the subgroup of children who could be followed up at 6 to 12 years old also supported the association of Embedded Figures Test impairment with maternal depression rather than schizophrenia, but unfortunately only 41 percent of the original psychiatrically ill mothers were available and allowed their children to participate.

Asarnow et al. (1977, 1978) found no significant performance impairment among offspring of schizophrenic mothers on the interference condition of the Stroop Color-Word Test, a task in which subjects are asked to name the ink colors in which color words (e.g., red) are printed, ignoring the linguistic information that does not match the ink color. The Stroop effect involves interference from the well-learned semantic associations to the printed words that automatically intrude. This automatic intrusion was apparently not significantly greater for the high-risk offspring.

Asarnow et al. (1977, 1978) found that these same adolescents with schizophrenic biological mothers were clearly slower than non-psychiatric comparison adolescents on the more difficult condition of the Spokes Test, a task that involves finding and connecting with a pencil an alternating sequence of letters and numbers that are randomly placed on a sheet of paper. Although the Spokes Test demands selection of the correct stimulus from the available letter and number stimuli at each step, it also involves sustained concentration on the sequencing of the stimuli and thus may be tapping deficits in sustaining focused attention, visual search difficulties, or both.

Another procedure that involves visual search involves scanning down rows of letters to identify a target letter under conditions in which the target letter either shares or does not share features in common with the distractor letters. This task was used by Neisser (1967) to examine aspects of preattentive processing, which should be particularly helpful when the target letter shares no features with the distractor letters. Winters et al. (1981) reported that children of schizophrenic mothers were significantly slower than children of normal parents in finding the target stimulus in such lists. Whether this deficit was particularly characteristic of the lists with targets similar or dissimilar to the distractors is not reported, so the relationship of this result to preattentive processing vs. focal attention remains unclear.

In summary, auditory selective attention appears to be somewhat impaired in persons at genetic risk for schizophrenia, with the deficit being found both on tasks allowing filtering (e.g., selection by ear of presentation) or demanding pigeonholing selection strategies (e.g., selection by meaning or context), although the former may be more subtle. The exact nature of the deficit has not been clarified, but performance impairment seems to be most apparent under conditions of high levels of competing information. Evidence for a deficit in visual selection among simultaneous stimuli that are presented at longer than tachistoscopic durations is somewhat inconsistent, although deficits are clearly apparent on a task that also involves sustaining focused attention.

**Sensory Storage and Read Out.** Certain of the tasks that have been used to examine populations at risk for schizophrenic disorder have been associated with investigation of certain stages of information processing in structural multistore models such as that of Atkinson and Shiffrin (1968). Among the procedures that have been associated with the initial sensory memory stage are backward masking and forced-choice span of apprehension.

Steronko and Woods (1978) selected college students with MMPI 2-7-8 profiles and examined their ability to recognize briefly presented, single, visual letter stimuli when they were followed by a visual pattern mask after various brief intervals. The 2-7-8 subjects required a significantly longer interval between target and mask to recognize the single letter targets than subjects without elevated MMPI profiles. Data supporting the hypothesis that schizotypal individuals require a longer interval to recognize single letters under backward masking conditions have also been reported by Saccuzzo and Schubert (1981) and Braff (1981) for patient groups defined by *DSM-III* schizotypal personality disorder criteria. Saccuzzo and Schubert (1981) found that the stimulus duration necessary for single letter recognition at 100 percent accuracy without a mask was not significantly different for schizotypal personality disorder adolescents

than for borderline personality disorder comparison adolescents, but schizotypal personality disorder subjects showed a visual masking function that indicated that they required a longer interstimulus interval to achieve the same recognition level as borderline personality disorder subjects when a pattern mask followed the target letter. Braff (1981) showed parallel results in comparisons of unmedicated schizotypal personality disorder patients and depressive disorder patients. The data of Saccuzzo and Schubert (1981) and Braff (1981) were obtained from patient groups and thus might reflect effects of clinical levels of psychopathology, but the fact that they parallel the findings of Steronko and Woods (1978) for nonpatient college student volunteers suggests that they are not secondary to gross psychopathology.

These backward masking results have usually been interpreted as indicating slow transfer from sensory (iconic) memory to short-term memory, because stimulus duration for recognition without a mask (which presumably indexes initial visual input factors) is unchanged and transfer from labile sensory memory to short-term memory is the last stage that is vulnerable to interruption by the pattern mask (Kahneman 1968). An alternative interpretation, however, can be derived from recent evidence that the mask impairs recognition across all interstimulus intervals not by interrupting processing of the target stimulus but by degrading the target through integration of the target and mask stimuli (Schultz and Eriksen 1977; Felsten and Wasserman 1980). Thus, the deficit could be explained by a lower perceptual sensitivity among schizotypal individuals in processing the montage created by the superimposed target and mask stimuli when mask elements are relatively salient, rather than by their slowness in reading the initial target stimulus into short-term memory (Nuechterlein 1983). A related interpretation of backward masking studies by Knight (in press) suggests that the greater interference by pattern masks may reflect an inability to reject the mask elements rapidly as irrelevant due to a perceptual organization deficit. All of these interpretations are compatible with a deficit in early perceptual processes.

The forced-choice span of apprehension procedure that has been applied to risk samples involves the tachistoscopic presentation of letter arrays. In each trial, subjects are required to identify which of two target letters appears (Estes and Taylor 1964). Because subjects need not report the identity of nontargets or even process the nontargets to the level of recognition, this task can estimate the efficiency of visual search in sensory memory more adequately than requiring the subject to report each letter in the arrays. Asarnow et al. (1977, 1978) found that foster children born to schizophrenic mothers, especially a deviant subgroup, identified significantly fewer target stimuli than foster children with nonpsychiatric biological parents or nonfoster normal comparison children as the number of irrelevant letters in the array increased. Recognition accuracy did not differ for arrays in which the target stimulus was presented without distractor stimuli. In a study of subjects drawn from temporary employment agencies, Asarnow, Nuechterlein, and Marder (1983) recently showed that young adults without a history of psychiatric disorder who had deviantly low scores on a large-array forced-choice span of apprehension task were characterized by significantly higher scores on the MMPI Schizophrenia scale, the Schizoidia scale (Golden and Meehl 1979), the Schizophrenism scale (Nielsen and Petersen 1976), and the Magical Ideation scale (Eckblad and Chapman 1983) than the balance of the subjects. Thus, data from children at genetic risk for schizophrenia, as well as from adults reporting schizotypal experiences, suggest that the efficiency of early visual search processes in the presence of multiple simultaneous distractors may be impaired in persons at risk for schizophrenic disorder.

The data summarized in this section suggest that deficits in early aspects of visual information processing may be present in persons at genetic risk for schizophrenia and those with schizotypal characteristics. The deficits are apparently detected under conditions in which the target stimulus must be discriminated from nontarget stimuli, but not when the target stimulus alone is presented. Either slowed posticonic processing or reduced sensitivity for signals in salient patterned noise might account for these deficits.

**Short-Term Recognition Memory.** Studies associated with the second storage structure, short-term memory, will be divided into those using recognition measures and those using recall measures, because recent processing capacity theories have emphasized that recall requires much more processing capacity and is more strongly influenced by active mnemonic strategies. Two studies of recognition memory have used signal detection theory analyses of sensitivity and response bias, thereby allowing signal-noise discrimination to be separated from response decision processes. Rutschmann, Cornblatt, and Erlenmeyer-Kimling (1980) used an auditory continuous

recognition task in which words or consonant-vowel-consonant trigrams were presented in a long series at a rate of one every 3.9 seconds. After each item, subjects were required to repeat the item aloud and to indicate whether the item was new or was a duplicate of an item presented earlier in the list. Adolescents with a schizophrenic parent had lower overall sensitivity (d') than children of normal parents in discriminating repeated items from new items, particularly for the more difficult trigrams, and this difference was found to be attributable to their weaker initial short-term memory strength rather than to a greater loss of information from memory.

Consistent with these results from a genetic risk sample, Koh and Peterson (1974) found that college students with 2-7-8 MMPI profiles had lower recognition memory strength as measured by d' than students without elevated profiles in a difficult condition of a delayed paired comparison task that examined memory for the number of dots in a random pattern. Similar to the conclusion of Rutschmann, Cornblatt, and Erlenmeyer-Kimling (1980), Koh and Peterson (1974) noted that the weaker memory strength of the group at hypothesized risk for schizophrenia was attributable primarily to impaired initial encoding or abstracting of an internal representation rather than subsequent differential memory decay.

The recognition tasks used in these two studies were chosen to limit the role of active mnemonic strategies, such as rehearsal and subjective organization. Thus, subjects at genetic risk and those with MMPI profiles believed to reflect schizotypal personality characteristics have been found to have impaired memory even under conditions in which such active memory processes are minimized.

Driscoll (in press) has reported a study that found no significant differences between children of schizophrenic mothers and normal comparison children in recognition of visual stimuli that were presented for intentional or incidental learning. The central task involved remembering a picture of a common object on each trial from an array of three pictures of common objects. Although there are many differences between this study and the two just reviewed, perhaps the most relevant is that the stimuli in this last study remained present until the subject pressed a response button, whereas those in the other two studies were presented relatively briefly (although not at typical tachistoscopic durations) and were externally paced. Subject-controlled exposure times and pacing may allow the subject to compensate for any subtle deficits in rapid initial encoding of stimuli. The fact that Nuechterlein et al. (1982) were able to isolate a disproportionately large number of poor performers among the same children of schizophrenic mothers with the CPT d' factor, but not with factors derived from subject-paced intentional or incidental learning tasks, is consistent with this suggestion.

**Short-Term Recall Memory.** Most of the tasks that have evaluated short-term recall among samples at risk for schizophrenia have also used relatively brief, externally controlled stimulus exposure times. Erlenmeyer-Kimling and Cornblatt (1978) found that children of schizophrenic mothers or fathers showed poorer immediate recall of letter sequences than children of normal parents in an Attention Span task in which three- or five-letter sequences were presented aurally at rates of either one letter or one-and-a-half letters per second. Significant differentiation of the children of schizophrenic parents was achieved only for trials with the longer sequences or the faster rate, which suggests that higher momentary processing load may be a relevant factor. It is also important to note that the addition of a distracting opposite-sex voice reading irrelevant letters between the relevant letters led to a large performance decrement for all subjects and a disappearance of the group differences, which Erlenmeyer-Kimling and Cornblatt attribute to making the task too difficult for all subjects. Thus, increasing the momentary processing load beyond some optimal point may exceed the processing resources of even the normal comparison subjects and diminish group differences by producing floor effects in test scores.

Cornblatt and Erlenmeyer-Kimling (in press) report that a second sample of 7- to 12-year-old children of schizophrenic parents was found to show similar poorer immediate recall for digit strings that were presented either aurally or visually in the Visual-Aural Digit Span test (Koppitz 1973).

An auditory digit span measure that was included in the first round of testing of the high-risk project of Neale and Weintraub (1975) also showed that children of schizophrenic patients recalled significantly fewer digits than children of normal parents, but only under a distraction condition in which an opposite-sex voice read irrelevant digits (Winters et al. 1981). The effectiveness of the distraction condition in this task, as compared to that of Erlenmeyer-Kimling and Cornblatt (1978), might be linked to the lower stimulus presentation rate of one digit every 2 seconds. Introducing irrelevant digits between relevant digits may bring the

processing load of this slower-paced task into a range in which deficient processing by the high-risk children is more detectable.

Harvey et al. (1981) and Neale (1982) have reported important additional analyses of data from a version of this task that suggest that the distractibility of children of schizophrenic patients is not wholly attributable to the increased overall processing load that distracting stimuli entail. These data come from the digit span task that Oltmanns and Neale (1975) developed to examine distractibility without the confounding psychometric effects of differential task discriminating power among normal subjects (Chapman and Chapman 1973, 1978). The difficulty level and reliability of the distraction and nondistraction conditions were matched among normal subjects by including more relevant digits in the nondistraction items than in the distraction items. Although a better, independent measure of overall processing load would be desirable, the matched difficulty level of these subtests can be taken as evidence of similar overall processing loads. Harvey et al. (1981) found that children of schizophrenic patients, compared to children of normal parents, showed a deficit only in the distraction condition, indicating that their distractibility is not a psychometric artifact nor is it caused wholly by increased overall task processing load.

Analyses of the serial positions within the digit strings that were disrupted by distraction showed that children of schizophrenic patients showed disruptive effects only for the digits presented in the early (primacy) serial positions (Harvey et al. 1981), a finding that parallels that of Oltmanns (1978) with adult schizophrenic patients. Consistent with Oltmanns' interpretation, Harvey et al. (1981) suggest that in children at risk for schizophrenia, the active rehearsal processes that are necessary to recall the early items within a digit string are easily disrupted by distraction, but the echoic storage and passive retrieval processes used to recall the most recent items are unaffected.

A remaining interpretive possibility for the Harvey et al. (1981) findings would tie in the deficits already reviewed. If high-risk children have either slowed posticonic processing or difficulty with the immediate discrimination of relevant and irrelevant recent stimuli, as might be expected based on research reviewed in previous sections, they might need to allocate a higher than normal amount of processing capacity to allow these initial processes to be continuously completed. This reallocation might not leave sufficient remaining processing capacity to complete the rehearsal that would be necessary to retain the early serial position digits. Thus, impaired active rehearsal could be a secondary effect of problems in earlier aspects of information processing.

The results of Driscoll (in press) indicate that children of schizophrenic patients did not show a recall deficit in memory for common objects that were presented in visual displays in the presence of other irrelevant objects, nor did they recall fewer of the irrelevant objects. As noted earlier, Driscoll used a subject-paced task with subject-controlled stimulus exposure durations, which may have allowed the high-risk children to compensate for any subtle time-linked difficulties in the initial encoding or selection of stimuli.

In summary, short-term recall performance has been found to be deficient in children at genetic risk for schizophrenic disorder, at least during tasks in which the subject cannot control the pacing and duration of stimuli and that create at least moderate overall processing loads. Even when overall task difficulty level is equated (but is not too extreme for normal subjects), short-term recall of children of schizophrenic mothers is impaired by distraction, which appears to interfere with rehearsal of earlier material. This interference may reflect a direct disruption of active rehearsal processes or a secondary effect of difficulties with earlier aspects of information processing that normally are completed very rapidly and with less demand on processing capacity.

**Concept Formation.** Another function that would be carried out in short-term, working memory is the formation of concepts. Asarnow et al. (1977, 1978) had subjects sort cards with varying numbers of irrelevant stimulus dimensions in a Concept Attainment task to examine how many trials were necessary for the subject to identify the sorting principle, which was known initially only to the investigator. Children of schizophrenic mothers took significantly more trials to achieve the criterion than community-reared children of nonpsychiatric parents. A deviant subgroup of high-risk children who were identified through cluster analysis of performance measures, however, was not distinguished by Concept Attainment scores.

Oltmanns et al. (1978) examined concept formation among children of schizophrenic parents using an object-sorting test in which subjects were asked to sort pictures of common objects into groups that were alike in some way and then to indicate the responses for their groupings. Children with a schizo-

phrenic parent gave more complex responses and fewer superordinate responses than children of normal parents. Complex responses are based on realistic relationships among items, but no single attribute applies to all group members, whereas superordinate responses involve a feature that is common to all group members. More recently, Winters et al. (1981) have reported additional analyses of the data from these children within the high-risk project of Neale and Weintraub (1975) using narrower criteria for schizophrenia, similar to those of *DSM-III* (American Psychiatric Association 1980), and Research Diagnostic Criteria (RDC) (Spitzer, Endicott, and Robins 1978) for unipolar and bipolar affective disorders. When these new groupings were used, differences among children with schizophrenic, unipolar, bipolar, or normal parents were directionally similar but no longer significant. Neale (1982) indicates that an attempt to isolate a deviant subgroup of children of schizophrenic parents on the superordinate response measure led to marginally significant results relative to the children of normal parents. Thus, while some results from measures of concept formation are promising, they have not been so clearly positive as for some of the other measures.

**Semantic Memory and Word Production.** The clinical emphasis on loosening of associations and related aspects of formal thought disorder as common characteristic symptoms in schizophrenic disorders has encouraged interest in the verbal associative network and speech production of samples at risk for schizophrenic disorders. Mednick and Schulsinger (1968) reported that children of chronically schizophrenic mothers produced significantly more clang associations, chain associations, and repetitions of the response words in a continuous association task in which subjects were given 1 minute to give all of the words that a stimulus word "makes you think of." However, Griffith et al. (1980) found that the initial deviant word association scores did not discriminate the high-risk children who received a consensus diagnosis of schizophrenia during the 1972–73 followup assessment of the high-risk children from the remainder of the high-risk group, thereby failing to support the predictive utility of these measures, at least for the first wave of schizophrenic breakdowns in this sample. An initial clinical interview rating of the train of associations, on the other hand, which referred to "the intelligibility of associative/sequential thinking," did predict a clinical diagnosis of schizophrenia spectrum disorder in this sample, although most of the early deviance on this measure was contributed by eventual borderline schizophrenic cases (Parnas et al. 1982). Thus, as Parnas et al. (1982) suggest, the phenomenon of predictive importance may not be associative deviation from one step to the next, but rather a lack of goal-directedness as a whole in conversational speech.

Two studies have examined referential communication in risk samples, using a task drawn from the work of Rosofsky, Levin, and Holzman (1982) and Cohen and Camhi (1967). The task requires the subject, taking the speaker role, to provide a one-word clue that will enable a listener to discriminate between two similar words, one of which is the "referent." Winters et al. (1981) found that children of schizophrenic parents gave significantly poorer clues than children of normal parents. With a difficult version of the task that Cohen and Camhi (1967) used with schizophrenic patients, Martin and Chapman (1982) showed that college students who scored deviantly high on the Perceptual Aberration Scale (Chapman, Chapman, and Raulin 1978) also gave less effective clues than subjects who did not obtain high scores on psychosis-proneness scales. Cohen (1978) notes that the speaker role, in contrast to the listener role, demands not only an intact associative network, but also the ability to self-edit those associates that would not help the listener discriminate the two stimulus words. Thus, if the deviations in these risk samples parallel those in adult schizophrenic patients, they might reflect failure to edit out unhelpful cues rather than a deviant semantic network (Cohen 1978).

In summary, the word associations of some children at genetic risk for schizophrenia tend to include more idiosyncratic responses and to drift away from the initial stimulus word more often than those of children with nonpsychiatric parents. However, the overall lack of goal-directedness in conversation may have more predictive importance than individual deviant associations. Referential communication deficits have also been found among genetic and questionnaire-defined risk samples, but these need not necessarily reflect deviant semantic memory structure.

## Studies of Actively Symptomatic Schizophrenic Patients

In this section, we focus on selected studies of actively symptomatic schizophrenic patients that use measures which are identical or very similar to those used with populations at risk for schizophrenic disorder. The findings with actively

symptomatic schizophrenic patients are compared to those obtained with risk populations. The studies chosen for review mainly concern actively psychotic schizophrenic patients, although the lack of documentation of the clinical status at the time of testing in some studies precludes clear conclusions about the presence of psychotic symptoms.

**Maintaining Readiness to Respond Over Time.** The large literature on schizophrenic simple reaction time has been analyzed in detail elsewhere (Nuechterlein 1977*a*; Mannuzza 1980). In the simple RT paradigm in which subjects are administered series of trials with regular (predictable) and irregular (unpredictable) preparatory intervals, chronic schizophrenic patients characteristically show both overall response slowing and often the crossover pattern that was illustrated earlier in figure 3. The crossover pattern has been shown to characterize particularly process schizophrenic patients, who demonstrate this pattern in 47–72 percent of cases using the Steffy paradigm of embedding sets of four trials with identical preparatory intervals within a longer series of trials with varying preparatory intervals (Bellissimo and Steffy 1972, 1975; DeAmicis and Cromwell 1979). Overall slowing of simple RT has been shown across multiple diagnostic groups (e.g., Olbrich 1972; Rosofsky, Levin, and Holzman 1982), but the crossover pattern has been shown to be highly prevalent only for process schizophrenic patients, temporal lobe lesion patients, and, in a much weaker form, for some groups of aged persons (Botwinick, Brinley, and Robbin 1959; Pfeiffer and Maltzman 1976; Greiffenstein et al. 1981; Strauss, Wagman, and Quaid 1983). Bohannon and Strauss (1983) have recently found that a smaller subgroup of bipolar patients (28 percent) diagnosed by Research Diagnostic Criteria (RDC) also manifested the crossover pattern using criteria that identified crossover in 47 percent of RDC schizophrenic outpatients.

The study by DeAmicis and Cromwell (1979) allows the most direct comparison between risk and schizophrenic populations, as they tested both groups under identical conditions. State hospital process schizophrenic patients showed marked overall slowness that did not characterize their first-degree relatives, who did not differ from normal comparison subjects in overall RT. As would be expected based on genetic transmission models as well as family morbidity rates, first-degree relatives showed the crossover pattern much less frequently than the patients themselves (17 percent of relatives and 47 percent of all of the patients by criteria that isolate no normal comparison subjects). Finally, some schizophrenic patients showed marked degrees of crossover that were not present in any first-degree relatives, although the mean pattern of these two groups was reasonably similar.

For the cross-modal RT paradigm, Spring (1980) also found that schizophrenic inpatients showed overall slowing that was not present in their siblings, although it was present to a similar degree in inpatients with major depressive disorder. Abnormal retardation in RT associated with changes from light to sound imperative stimuli in successive trials showed the same pattern. Retardation associated with changes from sound to light stimuli was significantly longer than normal only for schizophrenic patients.

These results suggest that overall simple RT slowing may be associated with level of psychiatric symptomatology within patient groups. Cross-modal retardation in RT shows a similar pattern, although certain forms may be associated more strongly with schizophrenic symptomatology. The crossover pattern shows some promise as a vulnerability indicator because of its presence in both risk and schizophrenic populations, although it is also found in a few other pathological conditions as well. Some change in the severity of the crossover pattern in the active schizophrenic period for some cases is suggested, although not directly demonstrated, by the available cross-sectional data.

**Sustaining Focused Attention Over Time.** Adult chronic, drug-free schizophrenic patients obtain significantly lower target hit rates than chronic alcoholic or normal subjects on the CPT, whereas chronic alcoholic subjects score significantly more poorly than schizophrenic or normal subjects on the Digit Symbol Substitution Test (DSST), a 90-second, self-paced, number-symbol transposition task (Orzack and Kornetsky 1966). The reversed pattern of performance deficit for the chronic schizophrenic and alcoholic patients suggests that the CPT taps a deficit with particular relevance to schizophrenia. The fact that this demonstration of CPT deficit involved a version with a single, clearly focused target letter (X) and exposure durations of 100 msec, the type of CPT version that has generally failed to elicit deficits among children of schizophrenic patients, indicates that a more severe information-processing deficit is present during the active schizophrenic period than is present among high-risk subjects. Given that the encoding and recognition of single,

highly familiar letters normally is automatic or at least requires very little processing capacity (Shiffrin and Schneider 1977; Posner 1978), these data suggest the possibility that information-processing dysfunction during the active symptomatic phase of schizophrenic disorder at times includes normally relatively automatic or low-load processes. It is possible that other task elements, however, such as the demand for sustained monitoring and rapid, selective response, lead to this impairment. Other sources of data that suggest broader information-processing dysfunction during the psychotic phase of schizophrenic disorder than during the premorbid period are noted below.

Further support for the relevance of CPT deficits to schizophrenic disorder rather than psychopathology generally comes from a recent demonstration that hospitalized schizophrenic patients achieve fewer CPT target hits (on a version using a sequential A–X target) than hospitalized patients with either schizoaffective disorder or major affective disorder, where all diagnoses are made by RDC (Walker 1981). The observation that abnormally low CPT target hit rates characterize only about 40–50 percent of hospitalized schizophrenic patients (Orzack and Kornetsky 1966), even when current narrower diagnostic standards for schizophrenia such as RDC are used (Walker and Shaye 1982), suggests that such poor performance might be characteristic of a more homogeneous subgroup of schizophrenic patients. Evidence supporting this possibility comes from findings that poor CPT performers are more likely than other schizophrenic patients to have a family history of serious mental illness (Orzack and Kornetsky 1971) and, more specifically, of schizophrenic disorder (Walker and Shaye 1982). Thus, these data regarding the extent of CPT deficit in schizophrenic disorder as compared to chronic alcoholism and major affective disorder, as well as the association of CPT deficit with a family history of schizophrenia, support the evidence from risk studies suggesting that this measure may index a vulnerability factor for schizophrenic disorder.

**Selective Attention With Immediate Response.** Dichotic listening studies provide the clearest comparisons of selective attention data from high-risk and active schizophrenic populations. Schizophrenic patients have typically made more errors in verbal shadowing of the relevant message, usually errors of omission, than comparison groups, suggesting that they are more distractible (Rappaport 1967; Payne, Hochberg, and Hawks 1970; Wishner and Wahl 1974; Schneider 1976; Hemsley and Richardson 1980), although this has not always been observed (Pogue-Geile and Oltmanns 1980). Most studies have not found that schizophrenic patients actually show increased intrusion of the words of the irrelevant message into their repetition of the shadowed message, although this intrusion of the irrelevant message has occurred in a few studies (Dykes and McGhie 1976; Wahl 1976). The observation that intrusion of stimuli from the irrelevant channel often does not occur more frequently than normal among schizophrenic patients when the messages are separated by ear of presentation may imply that gross impairment in filtering (Broadbent 1971) is usually not present. Impairment of shadowing performance associated with the specific personal relevance of the meaning of the nonshadowed channel (Schneider 1976) suggests that altered stimulus selection based on conceptual categories may be one source of schizophrenic deficit in dichotic listening.

However, Spring et al. (1983) have recently reported that schizophrenic patients, particularly those with florid psychotic symptoms, do show more intrusion of the irrelevant message than normal subjects, if analyzed at the phoneme level, even in a dichotic listening task that should allow filtering by ear of presentation. This result parallels their findings with relatives of schizophrenic patients. Thus, deficits in filtering may be present at this more subtle level. Furthermore, Spring et al. (1983) report that the correlation between the proband and the family average intrusion score was significant for schizophrenic patients ($r = .69$, $p < .005$) but not for bipolar patients ($r = .42$) or unipolar patients ($r = .17$). As Spring et al. note, this finding is compatible with the hypothesis that such intrusions are under greater genetic or other familial control for schizophrenic patients.

**Sensory Storage and Read Out.** Using the forced-choice span of apprehension task, Neale et al. (1969) and Neale (1971) demonstrated that the identification of the target letter in tachistoscopic presentations was impaired among symptomatic schizophrenic patients, as compared to nonpsychotic psychiatric patients and normal subjects, as the array size increased in the forced-choice span of apprehension procedure. Asarnow et al. (1978) and Asarnow and MacCrimmon (1978) showed that the pattern and level of impairment on this task was strikingly similar among acutely disturbed schizophrenic patients and among a subgroup of children born to schizophrenic mothers, suggesting that

forced-choice span of apprehension performance may serve as a vulnerability marker or indicator for schizophrenic disorder. Because manipulation of the similarity of target and distractor letters affected schizophrenic and normal subjects to a similar degree, Davidson and Neale (1974) concluded that slowed processing from sensory storage rather than an inappropriate visual search operation is likely to yield the schizophrenic deficit as array size increases.

Evidence from visual masking studies of symptomatic schizophrenic patients has paralleled that from schizotypal samples in finding that an abnormally long interval between a single letter target and a subsequent pattern mask is required for target recognition (Saccuzzo, Hirt, and Spencer 1974; Braff and Saccuzzo 1981; Saccuzzo and Braff 1981). This backward masking deficit does not characterize depressed or manic patients as diagnosed by RDC, *DSM-III*, and Feighner et al. (1972) criteria (Braff and Saccuzzo 1981; Saccuzzo and Braff 1981), although apparently patients with a manic syndrome and formal thought disorder have not yet been assessed. Furthermore, this deficit is more persistent across repeated test sessions among poor prognosis schizophrenic patients with a positive family history than among good prognosis schizophrenic patients without a family history of schizophrenia (Saccuzzo and Braff 1981).

In addition to the backward masking deficit, poor prognosis schizophrenic patients require longer stimulus durations to recognize single letters reliably without a mask than do patients with good prognosis schizophrenia, schizotypal personality disorder, depression, or manic disorder, who do not show impairment in recognition without a mask (Braff and Saccuzzo 1981; Saccuzzo and Braff 1981; Saccuzzo and Schubert 1981). These investigators suggest that the longer stimulus durations without a mask may involve preiconic or iconic deficiencies, whereas the increased target-mask interval for target recognition reflects slowed posticonic processing. The suggestion of possible iconic deficiencies seems to conflict with findings of intact iconic integration of immediately successive stimuli in schizophrenic patients (Knight et al. 1978; Spaulding et al. 1980) (although different properties of iconic memory might be involved), so the source of the recognition deficit for very brief unmasked stimuli remains unclear. However, it is noteworthy that information-processing dysfunction in the actively symptomatic period of process schizophrenia includes this aspect of deficient recognition that has not been identified in risk populations.

**Short-Term Recognition Memory.** The evidence of impaired short-term recognition among children of schizophrenic parents (Rutschmann, Cornblatt, and Erlenmeyer-Kimling 1980) and in college students with MMPI 2-7-8 profiles (Koh and Peterson 1974) tends to run counter to the majority of the literature on schizophrenic short-term memory, which stresses deficits in recall but not recognition (Koh 1978; Gjerde 1983). Two studies by Koh, Kayton, and Streicker (1976) are particularly relevant because they failed to find significant differences between schizophrenic patients and normal subjects in recognition of dot numerousness in a delayed comparison procedure, the same task that yielded lower recognition memory strength for MMPI 2-7-8 profile subjects (Koh and Peterson 1974). However, it may be noteworthy that a nonsignificant tendency ($p = .08$ and .12) for schizophrenic patients to have deficient recognition memory was present in these two studies. Furthermore, Koh, Kayton, and Berry (1973) found that schizophrenic patients did show poorer recognition for consonant-vowel-consonant nonsense syllables than normal subjects, but not for words, which parallels the Rutschmann, Cornblatt, and Erlenmeyer-Kimling (1980) finding that children of schizophrenic parents were more deficient in recognition memory for such nonsense syllables than for words. The less familiar nonsense syllables would impose a higher processing load on short-term recognition memory because they require more information storage for correct identification than the more redundant word items. Koh (1978) interprets the pattern of schizophrenic recognition deficit for low-association nonsense syllables in the Koh, Kayton, and Berry (1973) study as supportive of a deficit in efficiency of chunking the elements of the nonsense syllables for storage, an aspect of mnemonic organization.

The possibility of deficient recognition memory in process schizophrenia but not reactive schizophrenia has been suggested by Traupmann (1975), who found poorer word recognition in process schizophrenic patients than in reactive schizophrenic or normal subjects. He suggested that an information input dysfunction rather than retrieval deficits might explain his results, which would be consistent with the Rutschmann, Cornblatt, and Erlenmeyer-Kimling (1980) finding that initial memory strength rather than recognition memory decrement over time accounted for their results with children of schizophrenic parents. Thus, although the majority of short-term memory research with

schizophrenic patients reveals nonsignificant impairment in recognition memory, the risk population data may be congruent with findings from process schizophrenic patients and for recognition tasks with relatively high processing loads. Additional studies of the effect of the schizophrenic active psychotic state would be helpful for a clearer evaluation of the continuity of such deficits over time, as some of the most sophisticated available studies, such as those by Koh and his colleagues, have intentionally been completed while the patients were in a hospitalized, but nonpsychotic, state.

**Short-Term Recall Memory.** A deficit in recall memory has been found in a number of studies of schizophrenic patients (e.g., Nachmani and Cohen 1969; Bauman 1971*a*, 1971*b*; Koh, Kayton, and Berry 1973). In addition, early studies suggested that distraction exacerbates this deficit (e.g., McGhie, Chapman, and Lawson 1965).

The clearest comparison of recall in risk populations and actively symptomatic schizophrenic patients comes from the generally parallel findings of Oltmanns and Neale (1975), Oltmanns (1978), and Harvey et al. (1981) with auditory digit-span and word-span tasks. Oltmanns and Neale (1975) showed that recall of a series of digits was disrupted in chronic schizophrenic patients when an opposite-sex voice read irrelevant digits between the presentation of each relevant digit. This distraction effect is unlikely to be due to overall processing load effects, because the distraction items were matched for difficulty level and reliability with nondistraction items to avoid psychometric artifact associated with differential discriminating power of measures among normal subjects (Chapman and Chapman 1973, 1978). The extent of distractibility was also found to be positively related to the presence of formal thought disorder within a schizophrenic sample (Oltmanns, Ohayon, and Neale 1978).

Further steps to clarify the source of this distraction effect were undertaken by Oltmanns (1978) through an analysis of recall of words at various serial positions within strings of unrelated words. Schizophrenic patients were found to be impaired by distraction as compared to normal subjects for the first serial position in word strings but not for the last. Because recall of the first position is considered to involve active rehearsal processes to allow transfer of information to long-term storage, whereas the recall of the most recent item may involve more passive, relatively automatic processes, Oltmanns concluded that distraction in schizophrenic patients interferes with active rehearsal but not more passive, automatic processes. As noted earlier, Harvey et al. (1981) found this same serial position recall pattern among children of schizophrenic parents.

Schizophrenic patients also showed an excessive number of intrusions of irrelevant words from the end of the word strings into their recall performance. Oltmanns (1978) attributed these intrusions to the tendency of schizophrenic patients to rely on sensory storage, where both relevant and irrelevant words are represented, as a source of responses, because they do not have relevant items available from active rehearsal processes. These intrusions, however, would also be consistent with the alternative explanation that we noted earlier, which suggests that active rehearsal processes may not be completed because schizophrenic patients must devote too much processing capacity to successful completion of the earlier stages of processing stimuli, including rapid recognition and discrimination of relevant and irrelevant stimuli. Thus, intrusions of the most recent irrelevant stimuli may be a sign of difficulties in efficient immediate signal-noise discrimination.

A substantial body of additional evidence supports the deficiency in spontaneous usage of active, effortful, capacity-demanding processes in schizophrenia, including rehearsal (Koh and Kayton 1974), categorical clustering in recall (Koh, Kayton, and Berry 1973; Traupman 1975), and other mnemonic organization strategies (Koh 1978). The fact that experimental manipulations that encourage use of mnemonic organization can elicit appropriate strategies in schizophrenic patients suggests that these active short-term memory strategies may be diminished by an insufficient allocation of processing capacity rather than by structural defects (Koh 1978).

## Studies of Remitted, Postpsychotic Schizophrenic Patients

As we discussed in the introduction of this article, the presence of a deficit in information processing across premorbid, psychotic, and relatively remitted postpsychotic periods in individuals who develop schizophrenic disorder is a major source of evidence that the deficit may serve as a vulnerability indicator or marker for schizophrenic disorder. At present, only a few studies have specifically addressed the question of whether information-processing deficits continue into the postpsychotic period, or more dramatically, remain detectable even in asymptomatic periods in the subgroup of schizophrenic patients who show rather complete remission.

**Maintaining Readiness to Respond Over Time.** The simple RT paradigms that have been reviewed earlier have apparently not been applied to schizophrenic patients in a clearly nonpsychotic, relatively remitted state, although Strauss et al. (1979) and Bohannon and Strauss (1983) do report data from outpatient schizophrenic patients. Using the Steffy embedded set procedure, Strauss et al. (1979) showed that 55 percent of 36 former state hospital patients who were being maintained in the community on antipsychotic medication showed the RT crossover pattern. They found that the presence of crossover was not significantly related to a current global adjustment rating, but the degree to which these patients were manifesting psychotic symptoms at the time of testing is not reported. Bohannon and Strauss (1983) report a similar but slightly lower prevalence of crossover (47 percent) by more stringent crossover criteria in an outpatient RDC schizophrenic sample, but point out that some outpatient RDC manic patients (28 percent) also showed this level of crossover. As these authors note, a longitudinal study that examined the same schizophrenic and manic patients during floridly psychotic and relatively nonsymptomatic periods would help to clarify these results.

**Sustaining Focused Attention Over Time.** Wohlberg and Kornetsky (1973) administered conditions of the CPT to a group of schizophrenic patients who had achieved an unusually clear recovery from a schizophrenic episode. They required their schizophrenic subjects to be at least a year beyond their discharge from a single psychiatric hospitalization and to show educational, occupational, marital, and friendship patterns at least as stable as those characterizing their adjustment 6 months before the onset of the illness that led to hospitalization. Although they did not use criteria for schizophrenia that are as narrow as *DSM-III* or RDC, Wohlberg and Kornetsky did require that all patients show evidence of at least two of the following during their psychosis without signs of manic-depressive disorder or toxic psychosis: formal thought disorder, auditory or visual hallucinations or delusions, inappropriate emotional responsiveness, and withdrawn, bizarre, or regressive behavior. Virtually all (15 of 16) of their patients were drug free and none showed any signs of acute psychosis at the time of testing. Despite this excellent level of recovery, the remitted schizophrenic group obtained significantly fewer target hits than normal subjects during a CPT distraction condition and showed a similar but nonsignificant tendency in two nondistraction conditions. The additional finding of a significantly greater false alarm rate in baseline and distraction conditions suggests that these patients were likely to have lower sensitivity or signal-noise discrimination, although computations of this signal detection index from individual data would be necessary to confirm this source of the performance deficit. The version of the CPT employed by Wohlberg and Kornetsky (1973) involved a sequential target (a 5-9 trial sequence), exposure times briefer than in most studies of schizophrenic patients (50 msec), and flashing light and metronome distractors. Thus, it falls among the higher processing load versions, which, as we have noted earlier, have been successful in detecting deficits among populations at risk for schizophrenic disorder.

Asarnow and MacCrimmon (1978) examined acutely disturbed and relatively remitted schizophrenic patients to allow a direct comparison of their CPT performance. The relatively remitted patients were still receiving maintenance antipsychotic medication but were currently free of "major clinical symptoms (hallucinations, delusions, and affect disorder)" (Asarnow and MacCrimmon 1978, p. 600) at the time of testing. Asarnow and MacCrimmon found that both acutely disturbed and relatively remitted schizophrenic patients obtained fewer target hits and more false alarms than normal subjects, but did not differ significantly from each other. Their version of the CPT involved a single focused target (7), but, unlike the conventional CPT, the digits varied in position on the screen from trial to trial, and a recorded voice reading numbers added distraction in one of two conditions. The moving digits and distraction might be expected to increase processing load beyond that involved in detecting a single, clearly focused target without these features and make it more comparable in overall load to CPT versions that have detected deficits among risk populations. A tendency for the remitted schizophrenic patients to be differentiated from normal subjects most clearly in the distraction condition supports the view that increased processing load aids detection of information-processing deficit in relatively remitted schizophrenic patients.

Thus, these two studies of CPT performance in unmedicated and medicated postpsychotic schizophrenic patients suggest that deficits in sustaining focused attention in relatively high processing load conditions continue to be detectable in a state that is free of major clinical symptoms, even if the prepsychotic level of social and work functioning returns.

**Sensory Storage and Read Out.** Three studies of forced-choice span of apprehension performance during the postpsychotic period have been conducted by Asarnow and MacCrimmon (1978, 1981, 1982). Asarnow and MacCrimmon (1978), as part of the same study in which continued CPT deficits were found, showed that tachistoscopic identification of the target letter became significantly deficient, as compared to normal performance, among both relatively remitted and acutely disturbed schizophrenic patients as the size of the letter array increased. Furthermore, the remitted and acutely disturbed patients did not differ significantly from each other. The pattern and level of performance was very similar to that of a subgroup of offspring of schizophrenic mothers (Asarnow and MacCrimmon 1978). Asarnow and MacCrimmon (1981) extended this finding by showing that outpatient schizophrenic patients who were free from major clinical symptoms and had maintained a stable community adjustment for at least a year were more impaired in forced-choice span of apprehension performance than manic-depressive patients who met the same stability criteria. This difference was attributable to 40 percent of the schizophrenic patients who scored more poorly than all of the normal subjects, but who did not differ from the remaining schizophrenic patients in overall adjustment, specific symptoms, premorbid status, or demographic variables.

Asarnow and MacCrimmon (1982) examined a small number of schizophrenic patients 1 week after hospitalization and 12 weeks later as outpatients to examine the stability of forced-choice span of apprehension performance over changes in clinical state more directly. Compared to normal subjects tested at comparable intervals, the schizophrenic patients showed significantly poorer target detection across both sessions in the condition with the largest letter array. Initial span of apprehension performance was stable over time ($r = .74$) and predicted a measure of associative intrusions at the 12-week outpatient point ($r = .79$) but not overall level of 12-week symptomatology within these 10 schizophrenic patients. Although the extent to which the 12-week outpatient point represents a remitted state is not entirely clear, this study extends the previous findings by demonstrating that schizophrenic patients do have stable deficits on this task across a change in overall clinical state. Furthermore, Asarnow and MacCrimmon (1982) conclude that span of apprehension deficits may predict later cognitive performance associated with thought disorder.

The backward masking paradigm has also been applied to measurement of early aspects of visual information processing during the postpsychotic phase of schizophrenic disorder. Miller, Saccuzzo, and Braff (1979) examined poor premorbid schizophrenic patients who were "symptom-free" for at least 3 months, although still being maintained on antipsychotic medication and exhibiting poor social functioning. These patients showed poorer detection of the letter targets than normal subjects under backward masking conditions, suggesting that their performance is similar to that of schizotypal personality disorder patients (Braff 1981; Saccuzzo and Schubert 1981) and MMPI 2-7-8 profile college students (Steronko and Woods 1978). It is unclear whether these partially recovered patients also showed significant deficits in recognition without a mask at the very brief stimulus durations (2 and 4 msec) that were employed, making the attribution of the deficit to a specific masking source less secure, although pattern masks were particularly effective in increasing the deficit.

Saccuzzo and Braff (1981) found that good prognosis schizophrenic patients without a family history of schizophrenia showed backward masking impairment only during the initial sessions when they were acutely psychotic, whereas poor prognosis schizophrenic patients with a family history of schizophrenia showed a relatively stable impairment across eight inpatient testing sessions. Thus, the combined backward masking evidence across studies suggests the possibility that only poor prognosis schizophrenia and schizotypal personality disorder, conditions that have been linked genetically (Kendler, Gruenberg, and Strauss 1981), are characterized by a vulnerability to backward masking that is not associated with an acute psychotic state.

In summary, evidence from both the forced-choice span of apprehension procedure and visual backward masking suggests that at least a substantial subgroup of postpsychotic, partially recovered schizophrenic patients show a deficit on tasks that examine early aspects of visual information processing. The nature of the subgroup is unclear for the forced-choice span of apprehension results, but the backward masking findings seem to be tied to schizophrenic disorder with relatively poor prognosis and possibly with a family history of schizophrenia. The exact nature of this deficit needs further clarification. Strong correlations in the Asarnow and MacCrimmon (1982) 12-week posthospital admission data between span of apprehension letter identifi-

cation within large arrays and scores on the Trail Making Test (Reitan 1958), the Digit Symbol Substitution Test from the Wechsler Adult Intelligence Scale (WAIS) (Wechsler 1955), and an associative intrusion subtest (Rattan and Chapman 1973) suggest that the deficit might be impairing across tasks with a variety of specific demands. On the other hand, lack of significant correlations between span of apprehension performance and CPT performance among another small group of postpsychotic schizophrenic patients (Asarnow and MacCrimmon 1978) indicates that some more specific deficits might be involved.

**Short-Term Recall Memory.** Frame and Oltmanns (1982) administered a word span task adapted from Oltmanns' (1978) procedure to a small number of schizophrenic and depressed patients twice during an inpatient hospitalization, shortly after admission and after improvement in their clinical state. Schizophrenic subjects showed poorer overall recall and poorer recall for the first serial position within a word string than depressed or normal subjects on both occasions, but did not differ significantly for recall of the last serial position. This pattern across serial positions is consistent with that shown for other symptomatic schizophrenic patients (Oltmanns 1978) and for children of schizophrenic parents (Harvey et al. 1981). The pattern suggests that the active rehearsal processes of the schizophrenic patients continued to be deficient after improvement in their clinical status. The schizophrenic patients also displayed a significant improvement in overall recall and recall for the first serial position across the two sessions, suggesting that overall efficiency of recall was improving. Distraction effects were in the expected direction but not statistically significant for the eight schizophrenic patients in this study.

Because the second assessment in the Frame and Oltmanns (1982) study was completed during the inpatient stay, the continued presence of the recall deficits in more fully remitted schizophrenic patients needs additional examination. Laasi, Nuechterlein, and Edell (1983) presented a preliminary report from a small number of schizophrenic patients tested during a psychotic period and during an outpatient remitted period documented by the presence and absence, respectively, of symptoms in the clinical range on the psychotic scales of the Brief Psychiatric Rating Scale (Overall and Gorham 1962). Laasi, Nuechterlein, and Edell (1983) found that overall recall was significantly impaired across clinical state on the more difficult set of digit-span subtests developed by Oltmanns and Neale (1975). Furthermore, distraction impaired recall of schizophrenic patients across these sessions for early and late serial positions, whereas normal subjects showed no impairment by distraction in either session. The differential impairment of early serial positions by distraction was directionally consistent with previous cross-sectional studies (Oltmanns 1978; Harvey et al. 1981), but not statistically significant in these preliminary analyses with seven schizophrenic patients. Thus, both studies of short-term recall during the postpsychotic period indicate continued recall deficits that appear similar to those in the psychotic period, although larger sample sizes will be helpful in determining whether the deficit in the remitted state is wholly parallel to that in the psychotic period.

## Prediction of Course and Outcome

Although the prognostic implications of information-processing deficits among schizophrenic patients have received little research attention, one might expect that some vulnerability factors for schizophrenic disorder would have predictive value for the course of the disorder if they are present to varying degrees among individuals manifesting the disorder. Predictive utility might be particularly likely for vulnerability indicators that have a more immediate role in the causal chains leading to major schizophrenic symptoms. We have already noted that early evidence from followup of children of schizophrenic parents (Erlenmeyer-Kimling et al., in press *a*; Erlenmeyer-Kimling et al., in press *b*) suggests that some measures of sustaining focused attention predict later clinical deviance, including schizophrenia, among children of schizophrenic parents. In this section, we review the few studies of which we are aware that examined prediction of the course of illness within samples that had already developed schizophrenic disorder.

In an early study involving tasks with a prominent motor component, Weaver and Brooks (1964) examined 248 schizophrenic patients at a state hospital who were eligible for selection for a social rehabilitation program on a test battery that included simple reaction time with varying brief preparatory intervals, a tapping speed test, serial reaction time, a modified Purdue Grooved Pegboard Test, and a pursuit rotor task. Their results indicate that overall performance level across tasks was a good predictor of patient status at the end of a 2-year period of data collection. Patients who were able to leave the hospital even

without rehabilitation (and also tended to be less chronic at the time of testing) had shown the fastest and most accurate responses across five of six scores derived from the test battery; patients who left the hospital after rehabilitation had shown the next best performance; patients selected for rehabilitation but still in the hospital had usually obtained the next best scores; and patients who remained in the hospital and who had never been considered for rehabilitation had shown the slowest and least accurate performance.

Cancro et al. (1971) also employed a simple RT procedure, in this case within a cross-modal retardation paradigm, to examine 30 schizophrenic patients within 2 to 3 weeks after hospitalization before medications were administered. They found that simple reaction time (RT) level correlated .50 with the number of nights spent in psychiatric institutions over the subsequent 3 years. The simple RT level carried most of the predictive variance, although the addition of indices of RT slowing associated with cross-modal or ipsimodal changes in the imperative stimulus did substantially improve prediction of course for reactive schizophrenic patients. Simple RT was independent of depressive mood, social class, and the Phillips Prognostic Rating Scale.

A third study that examined the prognostic value of RT variables was completed by Zahn and Carpenter (1978; see also Zahn 1980) with 46 good premorbid acute schizophrenic patients at the National Institutes of Health Clinical Center. Patients were administered simple RT trials using the Shakow paradigm in drug-free periods about 3 weeks after admission and, in most cases, also 4 months later after a treatment period that emphasized psychosocial intervention. Eighteen patients who showed definite clinical improvement and substantial remission of symptoms over this period were found to have had significantly faster RT level at the initial test than 17 patients who showed minimal improvement. This differentiation by simple RT was possible despite the fact that neither global ratings nor symptom profiles from the Present State Examination at the time of testing differed for the two groups (Zahn 1980). The aspects of RT across varying preparatory intervals that contribute to the RT crossover effect showed expected directional trends but did not significantly differentiate these prognostically distinct groups. Although a few subjects with extremely poor performance at the initial test did show RT performance improvement over the 4-month period, no significant RT changes occurred for the clinically improved group as a whole over this period. Considering the faster RT as well as data showing greater cardiac deceleration during the preparatory interval among the patients who later improve clinically, Zahn and Carpenter (1978) suggest that these findings may be interpreted as indicating that acute schizophrenic patients who show greater responsivity to task demands have a better short-term prognosis than other acute schizophrenic patients with the same level of acute symptomatology. Indeed, the cardiac deceleration data do suggest that active preparatory processes were involved in the faster RT of the patients who later showed marked clinical improvement.

As noted earlier, Asarnow and MacCrimmon (1982) found that forced-choice span of apprehension performance 1 week after hospitalization did not predict the overall symptomatic level at an outpatient point 12 weeks later, but did significantly predict scores on an associate intrusion subtest that might reflect thought disorder (Rattan and Chapman 1973). The schizophrenic sample size ($n = 10$) was too small to allow any strong conclusions about the lack of significant predictive utility for the overall symptom level, but the prediction of the associative intrusion subtest score suggests that attempts to predict later clinical ratings of thought disorder and psychosis might be fruitful.

In a recent report, Pogue-Geile and Harrow (1983) have presented evidence that inpatient performance on the Digit Symbol Substitution Test of the WAIS (Wechsler 1955), which they interpret as an index of psychomotor retardation, is significantly, although modestly, predictive of overall functioning level ($r = .26$) and work functioning ($r = .36$) but not global symptomatic level for the year following hospitalization. This psychomotor speed and symbolic transposition task has not been among those that have been prominent possible vulnerability indicators for schizophrenic disorder, but these results are congruent with the results of the Weaver and Brooks (1964) study in indicating that psychomotor speed tasks have prognostic value within a group of individuals who have already developed schizophrenic disorder.

The overall impression that one derives from the few studies that have attempted to examine the prognostic utility of cognitive and psychomotor performance for the course of schizophrenia is that this area has considerable clinical and theoretical promise that has only begun to be explored. Results to date suggest that measures of the overall level of performance may have somewhat more prognostic utility than measures of more subtle aspects of performance (e.g., change in RT as a function of preparatory interval)

that have been more closely associated with characteristic schizophrenic deficits, but this impression is based only on measures from RT paradigms and rather global outcome measures. As noted earlier, slow overall simple RT level has not consistently been found to characterize populations at risk for schizophrenia and has been found to characterize nonschizophrenic psychotic patients as well as schizophrenic patients during symptomatic periods. Thus, this replicable prognostic indicator among schizophrenic samples might develop with psychiatric disorder but then serve as a useful index of the likelihood of continued poor functioning, at least within schizophrenia. Additional emphasis on prediction of various components of outcome seems necessary, as the Pogue-Geile and Harrow report (1983) has exemplified, because schizophrenic outcome is not unidimensional (Strauss and Carpenter 1972). Some vulnerability indicators might be linked to processes preceding schizophrenic psychotic symptoms and serve a useful role in the early detection of impending clinical relapse in addition to the prediction of the longer-term course of the disorder. Isolation of deviations in information processing that immediately preceded certain symptoms would also be of substantial theoretical interest as this time sequence would suggest a possible causal relationship.

## Conclusions and Implications

**Promising Vulnerability Indicators.** One of the primary purposes of this article has been to examine the current evidence that certain aspects of information processing and attentional functioning may be deficient in the premorbid, psychotic, and postpsychotic, relatively remitted phases of schizophrenic disorder and may thereby serve as promising indicators of vulnerability to schizophrenic disorder. Studies of populations at risk for schizophrenia have been examined as a means of identifying possible characteristics of the premorbid period and, in the case of first-degree relatives of schizophrenic patients, of identifying potential genetically influenced vulnerability factors.

Several of the measures that have been employed are promising vulnerability indicators for schizophrenic disorders by these criteria. The evidence for three measures that have shown similar deficits across risk populations, actively psychotic schizophrenic patients, and relatively remitted patients are summarized here. The versions of the CPT that involve a relatively high momentary processing load have detected deficits in sustaining focused attention in risk samples defined by genetic criteria (Rutschmann, Cornblatt, and Erlenmeyer-Kimling 1977; Nuechterlein 1983; Cornblatt and Erlenmeyer-Kimling, in press) or personality test criteria (Nuechterlein, Asarnow, and Marder, in preparation; Nuechterlein, Edell, and West, in preparation), in actively symptomatic schizophrenic inpatients (Asarnow and MacCrimmon 1978; Walker 1981), and in relatively remitted outpatient schizophrenic patients on medication (Asarnow and MacCrimmon 1978) as well as very well-recovered, single-hospitalization schizophrenic patients off medication (Wohlberg and Kornetsky 1973). Symptomatic patients who perform poorly are more likely to have a family history of schizophrenia (Walker and Shaye 1982) or serious mental illness (Orzack and Kornetsky 1971) than other schizophrenic patients, suggesting that a higher genetic loading might be involved.

Although the CPT perceptual sensitivity (signal-noise discrimination) deficits in populations at risk for schizophrenic disorder (Rutschmann, Cornblatt, and Erlenmeyer-Kimling 1977; Nuechterlein 1983) do occur in some hyperactive children (O'Dougherty, Nuechterlein, and Drew, in press), hyperactive children apparently differ from children of schizophrenic parents by showing a less cautious response criterion than normal children in signal detection analyses of CPT performance (Nuechterlein 1983; O'Dougherty, Nuechterlein, and Drew, in press). Children of schizophrenic parents show no abnormality in response criterion (Rutschmann, Cornblatt, and Erlenmeyer-Kimling 1977; Nuechterlein 1983). Furthermore, results to date suggest that inpatients with affective disorder and children of parents with affective disorder or nonpsychotic disorders outside the schizophrenia spectrum apparently do not show the CPT performance deficit that characterizes schizophrenic patients and some of their offspring (Walker 1981; Nuechterlein 1983; Erlenmeyer-Kimling et al., in press *b*), although more data on this issue would be helpful.

The forced-choice span of apprehension task has also detected a deficit in risk samples defined by genetic criteria (Asarnow et al. 1977) or personality test data (Asarnow, Nuechterlein, and Marder 1983), in symptomatic inpatients (Neale et al. 1969; Neale 1971; Asarnow and MacCrimmon 1978), and in relatively remitted outpatients (Asarnow and MacCrimmon 1978, 1981). Moreover, this deficit is relatively stable across a change in symptomatic state (Asarnow and MacCrimmon 1982). This deficit in tachistoscopic identification of a target letter among distractor letters

characterizes a subgroup of relatively remitted schizophrenic patients who do not differ from other schizophrenic patients in overall adjustment, specific symptoms, premorbid pattern, or demographic variables.

Although not as much research has been devoted to the question of the diagnostic specificity of the deficit measured by the forced-choice span of apprehension task as is available for CPT tasks, the available published data indicate that inpatient schizophrenic patients show greater deficit than inpatient nonpsychotic psychiatric patients (Neale 1971) and that schizophrenic patients show greater deficit than manic-depressive patients among relatively recovered outpatients (Asarnow and MacCrimmon 1981). A comparison of nonpsychiatric young adults with and without forced-choice span of apprehension deficit revealed that the poor span of apprehension subjects had significantly higher MMPI Schizophrenia and Psychasthenia scale elevations, but did not differ on other MMPI scales, which suggests some specificity among potential risk subjects (Asarnow, Nuechterlein, and Marder 1983). Data on psychotic patients with affective disorder and children of affective disorder patients would be very helpful.

Serial recall of digit or word strings in the presence of distraction has also been shown to be deficient in populations at risk for schizophrenia by genetic criteria (Harvey et al. 1981; Winters et al. 1981), in actively psychotic schizophrenic patients (Oltmanns and Neale 1975; Oltmanns 1978), and in postpsychotic, relatively remitted schizophrenic patients (Frame and Oltmanns 1982; Laasi, Nuechterlein, and Edell 1983). This deficit has usually (Oltmanns and Neale 1975; Oltmanns 1978; Harvey et al. 1981) but not always (Frame and Oltmanns 1982) involved a differential deficit in recall under distraction as compared to nondistraction conditions. The recall deficit has usually been present mainly for the early serial positions within a string rather than the late ones (Oltmanns 1978; Harvey et al. 1981; Frame and Oltmanns 1982), at least in the presence of distraction, suggesting that the schizophrenic recall deficit involves a lack of active rehearsal of the early items to allow their transfer to longer-term memory.

The interference with recall of early serial positions by distraction has been found to characterize children of schizophrenic parents, but not children of parents with unipolar or bipolar depressive disorder, suggesting considerable diagnostic specificity (Harvey et al. 1981). A group of manic inpatients who in many cases showed formal thought disorder tended to have a similar pattern of recall interference, leading Oltmanns (1978) to suggest that this distractibility pattern may be more closely related to formal thought disorder than to diagnostic category. Frame and Oltmanns (1982) did not find that recall of early serial items was deficient in depressed inpatients. Thus, diagnostic specificity appears to be substantial but not complete in findings to date. The possible linkage to formal thought disorder deserves more examination for this as well as other potential information-processing vulnerability indicators. The data on children of schizophrenic parents suggest that gross thought disorder need not be present for this deficit to be found.

Data from several other measures are also thus far consistent with the possibility that they may index a potential vulnerability factor, although these measures have not yet been applied to the same range of populations at risk for schizophrenia, actively psychotic, and postpsychotic, relatively remitted schizophrenic patients. Promising evidence across a risk sample and actively symptomatic schizophrenic patients has been found for the reaction time crossover effect (maintaining optimal readiness to respond over time to predictable as compared to unpredictable stimuli), dichotic listening (sustained selective attention with immediate response), letter recognition with backward masking as compared to without masking (sensory storage and rapid readout), short-term recognition memory if items involve a relatively high processing load, and referential communication (self-editing of associations to consider the listener's perspective). In the interest of space, this evidence will not be summarized here, although these measures may prove to be wholly as effective as those summarized in more detail.

**The Nature of the Deficits.** Several processes contribute to performance on each of the measures for which deficits have been demonstrated across risk populations, actively symptomatic schizophrenic patients, and postpsychotic, relatively remitted patients, making attribution of the deficits to any specific process difficult at this time. The variety of tasks and measures within tasks on which performance deficits have been found across the risk, actively symptomatic, and relatively remitted populations, however, suggests that a malfunction affecting a variety of elementary processes rather than a single deficient elementary process may be involved. Tasks with measures associated with a stage of information processing in structural models have not been employed extensively across the three types of populations that we reviewed. However, to the extent that they

have been used, measures associated with relatively early stages of information processing (e.g., backward masking, forced-choice span of apprehension) as well as later stages (e.g., active rehearsal of early serial position items within serial recall) appear to show deficits in level of functioning across these populations when the stage is sufficiently burdened.

Our frequent observation that tasks with high momentary processing load appear to detect deficits in populations at risk for schizophrenia and in remitted schizophrenic patients, whereas those with low processing load do not, suggests the tentative conclusion that a reduced amount of processing capacity available for task-relevant cognitive operations may underlie a variety of deficits on different performance measures in persons at risk or already manifesting a schizophrenic disorder. This conclusion emphasizes the intensive dimension of attention (Kahneman 1973; Beatty 1982) and would be consistent with inefficiency in completing cognitive operations that demand processing capacity (Shiffrin and Schneider 1977; Posner 1978, 1982; Hasher and Zacks 1979), despite normal information-processing structural components. A reduction in the available processing capacity is consistent with the findings, for example, that active rehearsal is deficient but more passive retrieval is intact in the serial recall data. Similarly, such a reduction could explain the lack of significant deficits among subjects at risk and remitted schizophrenic patients on continuous performance task versions with a single, highly familiar target stimulus which can be encoded to a recognition level with little processing capacity demand, but the presence of deficits in versions that employ a memory load or degraded stimuli that cannot be encoded automatically to a recognition level. This interpretation of the available evidence on cognitive vulnerability indicators is consistent with the deficits in controlled, serial, capacity-demanding processing but not passive, parallel, automatic processing in schizophrenia that have been postulated by Neale and Oltmanns (1980), Callaway and Naghdi (1982), and Gjerde (1983), and, for nonparanoid schizophrenia, by Magaro (1980).

The reduction in available processing capacity for task-relevant cognitive operations could, however, itself be caused by a number of different factors: (1) the executive decision-making or control function that allocates processing capacity is not responding appropriately to task demands despite a normal pool of processing capacity; (2) more processing capacity is devoted to task-irrelevant external or internal stimuli; (3) conscious, capacity-demanding processing is required to complete cognitive operations that are usually completed automatically in parallel processing; or (4) the total pool of processing capacity is smaller.

The functioning of the executive decision-making or control processes for the allocation of processing capacity might be examined empirically through procedures such as the secondary task interference paradigm that has been applied by Posner (1978, 1982) and others to the study of fine-grained aspects of processing within a simple task. The secondary task interference accompanying the individual cognitive operations required by the primary task could be examined to determine if similar patterns of processing capacity allocation are employed by normal subjects and schizophrenic subjects.

The second possible cause of a decrease in processing capacity for task-relevant cognitive operations appears to receive some support in the work on distractibility that has employed tasks that are matched for difficulty level and reliability to equate discriminating power among normal subjects (Oltmanns and Neale 1975; Harvey et al. 1981). Although this matching was completed to avoid psychometric artifact (Chapman and Chapman 1973, 1978), from our perspective it offers one means of trying to equate the overall processing load of two task conditions. Thus, the fact that irrelevant stimuli interfered more with recall in schizophrenic patients and children of schizophrenic parents than in normal comparison subjects, despite this matching of subtests on difficulty level, supports the possibility that these subjects devote more of the total pool of processing capacity to irrelevant stimuli.

It is notewothy that the role of task difficulty in this conception is not only a psychometric one. Matching information-processing tasks for difficulty level may entail a search for deficits that are not due to overall processing capacity limitations (Nuechterlein, in press *b*). From this perspective the "generalized deficit" described by Chapman and Chapman (1973) may incorporate a deficit in processing capacity that may be of theoretical interest and not only a source of psychometric artifact to be controlled. Additional examination of the relationship between task difficulty level and demand for processing capacity will be necessary if psychometric and processing capacity explanations of deficits are to be separated, as many cognitive theorists (e.g., Kahneman 1973) view task difficulty level as a major deter-

minant of processing load.

The third alternative that we have noted as a possible cause of decreased available processing capacity for active, task-relevant processing would suggest that cognitive processing that is normally completed automatically or with little demand for processing capacity is deautomatized. As discussed elsewhere (Nuechterlein 1982), deautomization of some early processes such as the initial encoding of the features of a stimulus might cause a reallocation of processing capacity to allow these necessary operations to be carried out by serial, capacity-demanding processes. Frith (1979, 1981) has proposed a conception of schizophrenia as a disorder in which normally automatic processes disturb conscious processing, which would be consistent with this alternative. Venables (in press) and Knight (in press) emphasize possible deficits in preattentive processing that would also have similar implications. More direct techniques for measuring whether automatic and preattentive processes are intact need to be applied across schizophrenic patients and risk populations before a deficit in these processes can be clearly ruled out.

**Deficits Occurring Only During the Active Symptomatic Period.** Certain performance deficits have thus far only been observed in actively symptomatic schizophrenic patients and not in populations at risk or in relatively remitted schizophrenic patients. The increased stimulus duration that is necessary to identify single letters (Braff and Saccuzzo 1981; Saccuzzo and Braff 1981) and poorer detection of single, highly familiar target stimuli during vigilance (Orzack and Kornetsky 1966) are examples. These tasks appear to be characterized by relatively low processing loads. From our perspective, these deficits in processing information during the actively symptomatic period could be due to either an additional reduction in the available processing capacity, such that even tasks with little processing load are affected, or a temporary disruption in automatic as well as attention-demanding processes during the acutely psychotic period. Because deficits of this low-load type have been associated mainly with the poor prognosis or already very chronic subgroup of schizophrenic patients and the antecedents of this form of schizophrenia have not yet been separated from those of other types in populations at risk, it is also possible that a stable, more severe, and more pervasive information-processing deficit characterizes this subgroup of individuals from the early premorbid period onward. Additional research following individuals through highly symptomatic as well as relatively remitted periods would help to separate these possibilities.

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# Family Therapy in Schizophrenia

*Family Therapy in Schizophrenia*, edited by William R. McFarlane, has been recently published by The Guilford Press (200 Park Avenue South, New York, NY 10003). Although family therapy originated nearly three decades ago through early efforts to understand the etiology of schizophrenia, it was all but abandoned in later years, as biological or constitutional factors were shown to contribute more to the occurrence of schizophrenia than family psychopathology. Though the etiology of the disorder is still understood in constitutional terms, recent findings suggest that the family—the key social unit in the patient's life—may have a substantial impact on treatment.

*Family Therapy in Schizophrenia* focuses on approaches developed since 1975. These approaches, brought together here for the first time, differ from earlier ones, according to McFarlane, in two important ways: "They seem to have major therapeutic effects on the schizophrenic process, beyond those achievable with drug therapy; and they all—with the exception of the systemic variety—start from a major expansion of family systems theory that includes extrafamily factors."

This volume presents practical strategies—developed by leading family therapists and researchers—for involving families of schizophrenics in the therapeutic process. The book is addressed to family clinicians, psychiatrists, rehabilitation counselors, psychiatric nurses and social workers, hospital and clinic administrators, and students in training for years to come.