Information-Processing Abnormalities: Trait- and State-Dependent Components

by Dennis P. Saccuzzo and David L. Braff

Abstract

Schizophrenics were compared to schizoaffective, bipolar, and nonpsychotic depressed patients in a visual masking paradigm in which an informational target stimulus was followed at varying intervals by a noninformational masking stimulus. In limiting the availability of the sensory signal provided by the target stimulus, the mask was used to probe how information from the environment enters and is processed by the central nervous system. The use of the masking paradigm was originally based on the hypothesis that thought disorder is a result of a more primary dysfunction in the processes that precede and result in thought. Results confirmed previous findings of a performance deficit in the schizophrenics when compared to nonpsychotic controls. Schizoaffective and bipolar patients also showed evidence of impaired processing, however. Results were interpreted in terms of a trait/state formulation in which impaired information processing is seen as a fundamental trait of schizophrenia spectrum disorders and as a state that can covary with psychotic illness in general. A unifying concept centers on the effects of psychopathological conditions on an individual's processing resources that results in either underprovision or overprovision of information from sensory input to complex cognitive operations dependent on the cerebral cortex. Findings from a variety of paradigms are consistent with those of the masking paradigm in revealing that the processing deficits of schizophrenics are time dependent and occur in the 500 ms following stimulus input.

Formal thought disorder is a chief defining characteristic of the group of schizophrenic disorders. In this context, information-processing approaches to schizophrenia view thought as the product of a number of stages or processes, such as the selection of relevant information from the environment, elaboration and interpretation of input, and the transfer of information throughout the nervous system. Information-processing approaches to the schizophrenias attempt to isolate an abnormality in the processes that result in thought. It is this underlying attentional or information-processing abnormality, not thought per se, that is viewed as the basic cognitive dysfunction in schizophrenia.

Venables (1964, 1973, 1984), for instance, has argued that disturbed thinking in schizophrenia can be traced to an "input dysfunction," in which, due to a disturbance in the central and peripheral mechanisms of arousal, schizophrenics take in either too much or too little information. Silverman (1964) similarly proposed that thought disorder was due to a "narrowing" or "broadening" of attention in which either too little or too much information was transferred to the higher cortical centers for analysis. Other theorists have pointed to a breakdown in a hypothetical filter that normally serves to screen out irrelevant input. The impaired filtering hypothetically causes the higher centers to become overwhelmed and results in distortions in abstraction and reasoning (Weckowicz and Blewett 1959; McGhie and Chapman 1961; Payne 1966). Still others have attributed thought disorder to an abnormally slow rate of information transfer, which results in critical losses of information and distorted interpreta-

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tions of events (Yates 1966). More recently, Callaway and Naghdi (1982) presented a model of schizophrenia as a disorder of information processing in which schizophrenics were seen as deficient in processing tasks characterized as conscious, serial, and limited in channel capacity. Processing tasks characterized as automatic, unconscious, parallel, and of very large capacity, by contrast, were hypothesized to be normal or supranormal. In this context, new evidence indicates that even apparently simple letter-detection tasks may fall into the serial-processing category (Sagi and Julesz 1985), thus accounting for the rather global deficits seen in schizophrenic patients' information-processing abilities.

The information-processing approach to the study of thought disorder in the schizophrenias is itself in the early stages of development (Kietzman, Spring, and Zubin 1980). There have been a number of important attempts to integrate existing findings along constructs such as hemispheric processing (Gur 1977, 1978; Magaro 1980), the developmental course of schizophrenia (Nuechterlein and Dawson 1984), and perceptual organization (Knight 1984; Kietzman and Zubin, in press). At present, however, there exists no fully developed or widely held model.

The current state of the information-processing approach to schizophrenia, its promise as well as its limitations and obstacles, is exemplified in studies involving the brief presentation of two or more stimuli in rapid succession, such as those involving visual masking. In a visual-masking paradigm, an informational target stimulus is presented in close temporal succession with a noninformational masking stimulus (Kahneman 1968). When a visual stimulus is presented for a short time and then is terminated, visual persistence and a host of possible individual differences in how the sensory signal might be stored and analyzed make it virtually impossible for a researcher to evaluate how the sensory impulse is experienced by the higher brain centers. The purpose of the noninformational masking stimulus is to limit the manner in which a sensory signal might vary, thus providing critical control of input. As Felsien and Wasserman (1980) state in their comprehensive review of the masking literature:

backward masking . . . limits the duration of the sensory signal itself . . . . [The mask] can be used to control the information content of the sensory signal representing the TS [target stimulus] . . . a mask permits the cognitive investigator to do something important that cannot be done by other means, namely, to deliver a pulse of information to the central nervous system with precise control on the duration of that pulse. Without . . . masking, visual persistence will guarantee that the duration of the information pulse experienced by the central nervous system will vary in an exceedingly complex manner. [p. 350]

To evaluate possible deficits in one stage of information processing, it is necessary to either control or minimize the demands on all other stages. Such was the goal in the first effort to apply the visual masking technique to schizophrenia. Saccuzzo, Hirt, and Spencer (1974) attempted to control for possible differences in the initial strength of the sensory impulse by determining the minimal target exposure duration for criterion accuracy for groups of paranoid and nonparanoid schizophrenics, nonpsychotic psychiatric patients, and normal controls. Then, to control the duration of the signal, target presentations were followed by a noninformational mask at intervals of 50, 100, 150, 200, and 300 ms following termination of the target. To minimize the effects of short-term memory and higher cognitive processing such as organizational strategies, the task was a simple twopoint discrimination of a capital "A" or "T." Results showed that the two control groups achieved the no-mask condition level of accuracy at the 150 ms interval. Schizophrenics, by contrast, did not approach their no-mask performance levels until the 300 ms interval. The findings, which revealed that schizophrenics required more time than controls to process the target and/or deal with the noninformational mask, supported the notion that there is a disturbance in the processes that precede and lead to conscious thought in schizophrenic patients.

The findings of Saccuzzo, Hirt, and Spencer (1974) have subsequently been replicated and extended under a variety of conditions, and have been shown to be highly reliable (Saccuzzo and Miller 1977; Braff and Saccuzzo 1981; Saccuzzo, Braff, and Sprock 1982; Schwartz, Winstead, and Adinoff 1983; Green and Walker 1984). The use of signal-detection methodology, which takes into consideration errors as well as correct responses, has ruled out differences in visual sensitivity and response strategy in the findings, indicating that the observed schizophrenic deficit in the masking paradigm is indeed due to impaired information-processing capabilities (Saccuzzo and Braff 1981; Saccuzzo and Michael 1984). Study of the effects of medication indicated that antipsychotic drugs may actually enhance the performance of schizophrenics in the masking and related attentionally dependent paradigms.
(Braff and Saccuzzo 1982). And by demonstrating quantitative as well as qualitative differences in the masking performance of schizophrenics and the elderly, who show generalized deterioration, Brody, Saccuzzo, and Braff (1980) have argued against generalized deficit as the primary factor in the poor masking performance of schizophrenics (see Saccuzzo 1977, for a discussion of generalized deficits in schizophrenia and old age).

Because no single study can reasonably be expected to cover all of the myriad possibilities, information-processing approaches to schizophrenia have required the support of a marshaling of evidence (Saccuzzo, in press). A series of studies, for example, dealt with the issue of whether the processing disturbance, as revealed by the masking paradigm, is simply the result of the disorder, or a more fundamental problem linked to its cause. Miller, Saccuzzo, and Braff (1979) studied the masking performance of remitted schizophrenics. Although free of significant thought disorder, these individuals exhibited the same poor performance as actively psychotic schizophrenics, supporting the conclusion that impaired processing is not dependent on the presence of thought disorder and, indeed, may be a more enduring feature of schizophrenia than the thinking disorder itself. In support of such a conclusion, Braff (1981) and Saccuzzo and Schubert (1981) independently demonstrated impaired masking performance in schizotypal personality disordered patients with a nonpsychotic schizophrenia spectrum disorder believed to be genetically linked to schizophrenia (Heston 1966, 1970; Meehl 1962). An important feature of Braff's (1981) study is that none of the schizotypal patients were receiving medication; yet, they were as impaired as a group of schizophrenics, most of whom were receiving antipsychotics. Such findings parallel those that emerge when related techniques are used to test remitted schizophrenics (Asarnow and MacCrimmon 1978) and children at risk for schizophrenia (Asarnow et al. 1978). The finding of impaired information-processing capabilities in schizophrenia spectrum disorders cannot be attributed to medication, hospitalization, or active thought disorder, according to Minnesota Multiphasic Personality Inventory (MMPI) studies, which have found poor masking performance in college students showing MMPI patterns associated with the schizotypic 2-7-8 code type and/or schizophrenic linked 8/9-9-8 code type (Steronko and Woods 1978; Merritt and Balogh 1984; Saccuzzo et al. 1984; Balogh and Merritt, in press; Nakano and Saccuzzo, in press).

That an information-processing disturbance, as revealed in the masking paradigm, may be a trait of certain subtypes of schizophrenics and only a state in others was revealed in a study of Saccuzzo and Braff (1981). Good prognostic schizophrenics were compared to poor prognostic schizophrenics and psychiatric as well as normal controls in eight experimental sessions during the course of their hospitalization in an acute care psychiatric hospital. The psychiatric controls consisted of a group of depressive neurotics and a group of manic controls demonstrating hypomania with no evidence of formal thought disorder. Results showed that the poor prognosis schizophrenics had a pronounced impairment in their ability to evade the effects of the mask for all eight sessions. The good prognosis schizophrenics, by contrast, showed improved masking performance as their clinical state improved. It was hypothesized that impaired information processing is a relatively pervasive and long-lasting trait of the poor prognosis schizophrenic patients. In addition, impaired processing was viewed as a more transient state of the good prognosis schizophrenic patients that covaries with their active psychosis and theoretically with their thought disorder.

If impaired information processing can be both a trait of the poor prognosis schizophrenic and schizotypal patients and a state that covaries with thought disorder, then one might expect to find evidence of impaired information processing in nonschizophrenic thought-disordered patients. Indeed, Schubert, Saccuzzo, and Braff (1985) found evidence of a continuum in the degree of information-processing impairment among schizoaffective, manic, and psychotic-depressive disorders. All three groups showed poor masking performance relative to nonschizophrenic psychiatric and normal controls, yet could be distinguished among themselves. Thus, unlike the less impaired manics tested by Saccuzzo and Braff (1981), the psychotically disturbed manics tested by Schubert, Saccuzzo, and Braff (1985) did show evidence of a masking disorder. It remained to be shown, however, whether schizophrenics could be distinguished from other psychotically disturbed persons, an issue that is addressed in the present article.

Method

Subjects. Forty-four psychiatric inpatients consisting of 11 schizophrenic disorders, 11 schizoaffective disorders, 11 bipolar affective disorders, and 11 nonpsychotic depressed individuals were tested. The schizophrenic, schizoaffective,
and bipolar affective disorders met the Research Diagnostic Criteria (RDC) of Spitzer, Endicott, and Robins (1977) for their respective groups. All diagnoses were determined by a senior psychiatrist (D.L.B.) and a trained research assistant. The nonpsychotic depressed group met the RDC for a minor depressive disorder. This group provided a nonpsychotic control group. The groups were matched on age and intelligence as evaluated by their scaled score on the Vocabulary Subscale of the Wechsler Adult Intelligence Scale. Single classification analysis of variance indicated no significant differences for either of these variables ($p > .05$). The groups did differ on the Global Assessment Scale (GAS) (Endicott, Spitzer, and Fleiss 1976), both in lowest GAS score ($F = 6.34, df = 3/40, p < .005$) and overall GAS score ($F = 8.55, df = 3/40, p < .001$).

Table 1 provides the means for age, scaled score on Vocabulary, and GAS scores for the four groups.

Newman-Keuls analysis of the lowest GAS score indicated no differences in the level of severity of impairment between the schizophrenics and schizoaffectives. Both of these groups, however, were significantly more impaired than the bipolar disorders ($p < .05$), who in turn were more impaired than the nonpsychotic depressed group. These findings were paralleled by those for the overall GAS score.

Patients were screened for a history of central nervous system (CNS) damage, mental retardation, electroconvulsive therapy, and severe polydrug use. All subjects had at least 20/30 vision.

**Apparatus and Stimuli.** Stimuli were presented in a Gerbrands four-field tachistoscope. Stimuli were constructed by mounting black paraphrase (Futura bold No. F29-14) upper case A's and T's on white stimulus cards. With a viewing distance of 78.7 cm, stimuli subtended a visual angle of .20 degrees when presented in the center of the visual field. Five T's and A's were constructed and presented in random order in blocks of 10. The mask consisted of overlapping X's, completely superimposed over the letters. Luminance of the target and masking fields was set at 15 footlamps. A small dot presented just above the center in field 3, illuminated at 1 footlambert, provided a fixation field.

**Procedure.** After they provided written informed consent, subjects were escorted to a dimly lit experimental room where they were read a standard set of instructions (Saccuzzo, Hirt, and Spencer 1974). To ensure that subjects were attending to the task, the experimenter preceded the presentation of each stimulus card with the statement, “Ready, look.” In phase 1 of the experiment, the minimum exposure duration for criterion identification of the test stimulus without a mask, which Saccuzzo et al. (1979) called the “critical stimulus duration” (CSD), was calculated for each subject. The procedure for calculating the CSD followed that used by Saccuzzo et al. (1979) and Braff and Saccuzzo (1981). Briefly, the target stimulus duration was initially set at 1.0 ms and increased in increments of 1.0 ms for each incorrect response until the subject reached the criterion of seven consecutive correct identifications. The CSD provides a suprathreshold exposure duration (see Saccuzzo and Schubert 1983).

**Table 1. Mean age, Vocabulary, Global Assessment Scale (GAS), and critical stimulus duration (CSD) scores**

<table>
<thead>
<tr>
<th></th>
<th>Schizophrenic</th>
<th>Schizoaffective</th>
<th>Bipolar</th>
<th>Non-psychootic depressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age: Mean</td>
<td>27.18</td>
<td>26.82</td>
<td>28.73</td>
<td>26.64</td>
</tr>
<tr>
<td>SD</td>
<td>5.51</td>
<td>6.42</td>
<td>7.18</td>
<td>7.28</td>
</tr>
<tr>
<td>Vocabulary: Mean</td>
<td>10.27</td>
<td>11.64</td>
<td>11.73</td>
<td>10.73</td>
</tr>
<tr>
<td>SD</td>
<td>2.87</td>
<td>2.94</td>
<td>1.74</td>
<td>2.05</td>
</tr>
<tr>
<td>GAS, lowest: Mean</td>
<td>30.91</td>
<td>30.82</td>
<td>37.64</td>
<td>48.55</td>
</tr>
<tr>
<td>SD</td>
<td>9.40</td>
<td>8.80</td>
<td>14.14</td>
<td>10.87</td>
</tr>
<tr>
<td>GAS, overall: Mean</td>
<td>4.91</td>
<td>5.27</td>
<td>4.73</td>
<td>3.36</td>
</tr>
<tr>
<td>SD</td>
<td>1.04</td>
<td>0.79</td>
<td>1.10</td>
<td>0.81</td>
</tr>
<tr>
<td>CSD: Mean</td>
<td>12.18</td>
<td>18.18</td>
<td>13.09</td>
<td>6.36</td>
</tr>
<tr>
<td>SD</td>
<td>15.58</td>
<td>18.33</td>
<td>17.39</td>
<td>4.86</td>
</tr>
</tbody>
</table>

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this experiment, the advantage of ruling out possible intergroup differences in the ability to identify unmasked targets outweighed the possibility of influencing the masking functions in different ways for different subjects. It is true that in normals longer durations shorten the range of the masking function for any given subject (Turvey 1973). Such findings, however, are based on the unlikely assumption of no individual differences of the strength of a sensory signal for any given duration.

In the present experiment, masking functions were calculated for four intervals between termination of the target and presentation of the mask (i.e., interstimulus intervals). These were 20, 60, 120, and 300 ms. A no-mask control was also used, which is an infinite interval between the two stimuli. For each interval, there were 10 consecutive presentations of the randomly presented T or A. The mask was presented for 50 ms, which provided a mask energy that always exceeded that of the stimulus regardless of a subject's CSD. A typical masking trial was as follows: The subject fixed on the dot in the center of the visual field. The stimulus was presented at the previously determined CSD. There then followed a dark interval at one of the four interstimulus intervals. Then the mask was presented. Subjects reported orally, “T” or “A.” If no response was given or if they were not sure, subjects were instructed to guess T or A before the next trial began.

**Results**

Table 1 presents the mean CSDs for the groups. A single classification analysis of variance revealed no statistically significant differences in these means. Indeed, the range of CSDs for the three psychotic groups was less than 6 ms. However, because the mean of the nonpsychotic depressed group was more than two times smaller than that for the three psychotic groups, a series of individual t tests were conducted in which each group was compared to each of the others. Significant differences were found between the nonpsychotic depressed group and each of the other three (p < .05), indicating this group's target exposure duration was indeed below that of the three other groups.

Results for the masking experiment were evaluated in a 4 (Group) × 5 (Interstimulus Interval) repeated measures analysis of variance with repeated measures on the last factor. There were significant main effects for Group (F = 4.34, df = 3/40, p < .01) and Interstimulus Interval (F = 68.37, df = 4/160, p < .001). The Group × Interstimulus Interval interaction was also significant (F = 1.85, df = 16/160, p < .05).

Newman-Keuls analysis of the main effects indicated no statistically significant differences among the schizophrenic (M = 6.00), schizoaffective (M = 6.49), and bipolar (M = 6.64) disorders (p > .05). All three of these groups, however, were significantly below the nonpsychotic depressed group (p < .01). (See figure 1.) Newman-Keuls analysis of the main effect for Interstimulus Interval revealed the typical finding that as the interval between the stimulus and mask increased, so did performance. Newman-Keuls analysis of the interaction indicated that at the 20 ms, 60 ms, and no mask intervals, when subjects were performing approximately at chance or ceiling, none of the groups differed significantly (p > .05). At the 120 ms and 300 ms intervals, the depressed group was significantly better than all other groups (p < .01), who did not differ significantly from each other.

**Discussion**

The data revealed that schizophrenic patients could not be distinguished from the schizoaffective and bipolar affective patients on a cross-sectional basis, with all three groups showing evidence of a masking deficit. Consistent with Schubert, Saccuzzo, and Braff (1985), the data indicate an information-processing dysfunction in actively symptomatic schizoaffective and bipolar-disordered patients. These results, in conjunction with our previous findings, are consistent with an interpretation of information-processing dysfunction as both an enduring trait of patients with schizophrenia spectrum disorders and as a state that probably covaries with the presence of thought disorder and psychotic symptoms in psychotically disordered patients.

From a theoretical standpoint, there remains the question of why actively psychotic patients have difficulty with the masking task. One possibility, which we have favored (Saccuzzo, Hirt, and Spencer 1974; Saccuzzo and Braff 1981), is that the schizophrenia does not rapidly transfer input to more complex cognitive operations that theoretically are dependent on cerebral cortical mechanisms. This information transfer problem results in underprovision of accurate information due to temporal processing limitations and ultimately leads to distortions of reality testing. It is also possible, however, as suggested by Knight (1984), that at least some schizophrenics process too much infor-
Figure 1. Backward-masking performance of schizophrenic, schizoaffective, bipolar, and nonpsychotic depressed inpatients

Interstimulus Intervals (msec)

Mean Number of Correct Detections

- Schizophrenics
- Schizoaffectives
- Bipolars
- Nonpsychotic Depressives

Information because they allocate unnecessary resources to the processing of an irrelevant, noninformation mask. In this case, the problem would be overprovision of information, a formulation in accord with impaired filter theories of schizophrenia. A unifying concept is that psychotic states deplete an individual's processing resources, putting an additional strain on an already limited system that leads to impaired performance for all tasks that require the full use of processing capabilities (Nuechterlein and Dawson 1984).

The idea that cognitive dysfunction in schizophrenia is due to alternating underprovision (or underutilization) or to overprovision (or overutilization) of input is consistent with the traditional theories of schizophrenia advocated by Venables (1964), Silverman (1964), McGhie and Chapman (1961), Weckowicz (1958), Yates (1966), and others. Cast in the context of psychophysiological (Venables 1984) and psychopharmacological (Matthysse 1974) formulations, information-processing studies of schizophrenia support a general theory in which poor prognosis/poor premorbid schizophrenics and genetically linked spectrum-disordered patients can be characterized by underprovision or overprovision of cortically dependent operations, caused by an imbalance in normal disinhibitory or inhibitory processes. According to the ideas of Venables (1964) and Mednick (1958), an affected individual might be plagued by overprovision at one point in the disorder that is followed at another point by overcompensation and then underprovision at some later time. The reverse might also be true, with some individuals beginning with an imbalance that leads to underprovision followed by overcompensation. Still others might be afflicted with a lifetime imbalance in only one direction. Unfortunately, such complex and variable formulations seem somewhat inconsistent and are not easily disconfirmed. However, this sort of formulation does lend itself to a nonlinear topographic analysis (Winfree 1983) that may ultimately prove of great utility in analyzing data from schizophrenic-disordered patients. Such nonlinear approaches also encourage researchers to obtain multiple, detailed dependent measures on schizophrenic patients in order to chart the time course of schizophrenic deficits. This type of formulation is quite consistent with Bleuler's (1950) original idea that there is a heterogeneous and complex group of schizophrenias.

Based on the ideas of Meehl (1962) and those of Zubin and Spring (1977), it seems reasonable to assume that an information-processing dysfunction may vary on a continuum of severity across afflicted individuals. If it is extreme, then the impaired processing will almost certainly lead to the development of a thought disturbance. At less severe levels, the processing impairment might affect personality and social functioning but not necessarily, or by itself, cause thought disorder. Individuals whose inhibitory-disinhibitory imbalance leads to information overutilization will manifest hypersensitivity and painful anxiety, especially in social situations. When the imbalance leads to underutilization, the individual becomes grossly insensitive to social stimuli. Missing many of life's subtleties, the individual fails to experience its rewards and there is a strong tendency to social withdrawal. Whether the individual experiences a full-blown schizophrenic disorder depends on a number of factors.
including the stability of the personality organization that evolves, the flexibility and effectiveness of learned coping strategies, and, as suggested by Zubin and Spring (1977), the severity of the processing impairment in relation to the degree of environmental stress.

When a high-risk (i.e., severely impaired information-processing) individual with an unstable personality organization confronts stressful events that overtax existing coping skills, limited processing resources become further strained. A vicious cycle may ensue in which strained resources further limit the individual's capacity to cope, which, in turn, enhances the impact of the stressful event, causing a still further drain of resources. Eventually the individual becomes overwhelmed. Consciousness either spills over with an uncontrollable flood of input or becomes brittle and fragmented. And when the episode is over—the major symptoms brought under control by medication and therapy or by natural cyclic remission, the individual's processing capabilities revert to their previous marginal levels while the sequelae of a schizophrenic episode may linger on. Once this path has been traveled, it is somehow facilitated so that it becomes more easily followed when the next processing storm occurs.

Current Status of the Icon and Visual Masking Mechanisms. Interpreting the results of visual information-processing experiments is far from easy. Allik and Bachmann (1983) have pointed out that 50 to 100 experiments are published each month about visual information storage, iconic memory, visual persistence, and related issues. Since Sperling (1960) originally argued that there is a large capacity, short duration store of visual information, thousands of studies have been completed on the issue of initial visual storage as high capacity, evanescent, information store, termed iconic storage by Neisser (1967). Related to iconic storage, the phenomenon of visual persistence has been unequivocally demonstrated, but the theoretical significance and anatomical locus of such persistence has been debated, dissected, and disputed. Is there a retinally or centrally based informational store? Is there a need to deify such a storage capacity with a special place in a sequential information-processing theory? After hundreds of studies and countless hours of debate, researchers have reached no clear consensus about this issue. Haber (1983) has commented extensively on the "demise of the icon" and the "sharp empirical debates" that this issue has engendered. To illustrate the sheer weight of this literature, Haber (1983) notes that Long (1980) and Coltheart (1980) have produced two lengthy reviews of over 60,000 words and that neither of these authors ever raises any of the questions or concerns posed by theorists such as Neisser, Hochberg, Eriksen and Schultz or Turvey" (Haber 1983, p. 3). Haber's 11-page article received "open peer commentary" from 32 authors, and there was wide disagreement about the utility and accuracy of theories of iconic memory. If the issue of iconic memory is controversial when measured in small groups of normal subjects, this complexity is greatly increased when a masking paradigm is used in groups of psychopathological subjects.

Still, we can summarize the state of the literature in this area:

• A visual stimulus creates a retinal response that decays over time.

• This retinal response has central correlates.

• The visual response persists after stimulus termination, and this persistence probably has retinal and central components.

• The visual response can be analyzed for information content and is also subject to interference by masking.

• Theories of iconic memory as a static, purely retinally based "photograph" are outdated and not particularly useful.

Unfortunately, this evaluation leads to a more complicated question. How does the mask act in a visual masking paradigm? Is its major effect retinal or central? Is the masking mechanism integrative or interruptive? The answer is that masking can act retinally or centrally. It also can probably act via the "merging" of target and mask stimuli (integration) or via the interruption of target processing via the action of the mask ( interruption). All of these mechanisms are possible, depending on the specific conditions of the experiment (Felsten and Wasserman 1980).

Visual Processing in Schizophrenic Patients. For our purposes, we should examine the conditions of our typical visual masking paradigm using schizophrenic patients. In our studies of psychopathological subjects, we have used a dark adaptation period that tends to increase the duration of visual persistence to stimuli. We have also used a target duration (whether fixed for all subjects or at the CSD) close to the visual identification threshold and a powerful (bright and long duration) mask to limit visual persistence and to control the pulse duration of information delivered to
the subject. Under these conditions, we initially felt that at longer ISIs (> 100 ms), masking acts through central interruptive mechanisms. According to this formulation, the masking paradigm performance deficits of schizophrenic patients reflect a slowness of information processing. In addition some schizophrenics, as we have noted, also show deficient processing of unmasked stimuli, as revealed by increased CSDs (Saccuzzo, Hirt, and Spencer 1974; Braff and Saccuzzo 1981). Initially we interpreted such CSD findings as evidence for a deficit in input capabilities in some schizophrenics. Additional studies have not definitively resolved this issue.

Knight and colleagues (e.g., Knight, Sherer, and Shapiro 1977; Knight and Sims-Knight 1980) used a picture integration technique and concluded that schizophrenics had normal information-processing functions in the first 100 ms following stimulus input. Using a dot integration procedure, Spaulding et al. (1980) reached similar conclusions. In related work, however, Schwartz, Winstead, and Adinoff (1983) specifically evaluated speed of information processing in schizophrenic patients and normal controls using a backward-masking paradigm with varying target stimulus durations and other paradigmatic manipulations to evaluate iconic and visual persistence factors. They concluded that the retarded processing shown by schizophrenics is due, at least in part, to visual signal abnormalities caused by an instability or a slower than normal rate of decay of visual stimuli. Schwartz, Winstead, and Adinoff (1983) interpret their findings as suggesting that temporal integration is defective in schizophrenia, perhaps due to increased target stimulus visual persistence. Thus, the status of information processing at the iconic level has yet to be fully understood.

With debates raging over the theoretical interpretations of iconic and masking factors, a relatively atheoretical and clear descriptive approach seems warranted. Varying interpretations of masking experiments abound. For example, it is quite clear that if schizophrenics show deficits in visual persistence, their masking deficits may occur via integrative (versus interruptive) mechanisms at retinal or CNS levels. In normals, there is evidence that masking by integration yields complex stimuli that register event-related potentials (ERPs) intermediate between target and mask ERPs (Schwartz, Whittier, and Schweitzer 1979). This “mixed” ERP occurs even when the target cannot be consciously identified. When a second mask is used, the original mask becomes ineffective and the target is once again correctly identified, but the ERP to the target-mask stimulus is unchanged. Perhaps the defect shown by schizophrenics in the visual masking paradigm results from their inability to screen out the mask features from the target-mask stimulus and to identify the critical target-identifying features from the montage of a fused or complex target-mask stimulus. The physiological basis for this phenomenon would be slowed rates of resolution of the visual response to the target and mask stimuli. Thus, the visual information-processing data in schizophrenics could be reinterpreted along the lines of impaired filters as well as slowness of processing.

Lest we confound issues further, suffice it to say that the visual masking paradigm has usefully and clearly identified schizophrenic patients' deficits in the epoch of 500 ms after stimulus presentation (Braff and Saccuzzo 1984). Thus, a number of related paradigms, using auditory and visual processing systems, show strikingly similar time-linked deficits in schizophrenia spectrum patients (Braff 1985). For example:

- Braff, Callaway, and Naylor (1977) examined self-stimulated auditory ERPs where the subject triggers the ERP-eliciting stimulus after a delay. Normally, ERP amplitude is inhibited in the self-stimulated versus randomly presented conditions. Schizophrenics, though, seemed to show loss of normal amplitude inhibition in the 250 ms “ISI” condition (the ISI being the delay between key release and stimulus presentation). These results were interpreted as supporting a loss of normal inhibitory or sensory gating influences in information processing in schizophrenic patients.

- Freedman's group has used an ERP paradigm that reflects sensory gating. In a series of systematic and revealing studies, this group has...
examined the ERP $P_{50}$ wave to paired stimuli with a 500 ms conditioning ISI. The second stimulus-elicited $P_{50}$ wave is normally inhibited by the effects of the first stimulus. Schizophrenic patients and their first degree relatives share a loss of normal inhibitory influences as reflected by increased $P_{50}$ waves to the second stimulus (Adler et al. 1982; Freedman et al. 1983; Siegel et al. 1984). Interestingly, Freedman's group also reports that this gating or inhibitory abnormality seems related to a trait-dependent schizotypal factor and a transient, state-dependent factor that occurs in bipolar manic patients (Franks et al. 1983). These results provide a striking parallel to the visual masking trait/state formulation.

Adler, Rose, and Freedman (1985) have also recently reported success in creating an animal (rodent) model of their $P_{50}$ gating paradigm which will allow this group to test specific neurobiological hypotheses about the observed $P_{50}$ abnormalities.

- A third related line of evidence utilizing human and animal data in the 50 to 500 ms interval following stimulus input has evolved from experiments using the prepulse inhibition (PPI) of the acoustic startle response (ASR). This paradigm uses the blink reflex (in humans) or whole body startle (in rats) to strong auditory stimuli. Normally, weak prestimulation at certain ISIs inhibits the ASR amplitude in normal humans. Braff et al. (1978) reported the loss of this normal prepulse inhibition (PPI) effect in the 60 ms ISI condition in a group of schizophrenic patients. This time-linked deficit is parallel to the findings of Freedman and associates. To assess the possibility that this loss of PPI is due to dopaminergic dysfunction, Swerdlow et al. (1986), using stimulus parameters similar to those used in humans, stimulated rats' supersensitive dopamine receptors with low-dose apomorphine and found a loss of normal PPI of the ASR with mesolimbic (nucleus accumbens) but not frontal cortical supersensitive dopamine stimulation. This result was also time dependent and loss of normal inhibition was maximal in the 60 and 120 ms ISI conditions. These findings added significant support to the idea that the observed time-linked abnormalities in schizophrenic performance may well be linked to the putative underlying increase in mesolimbic dopaminergic tone in schizophrenic patients.

- There are a host of other, less time-linked deficits in auditory and visual information processing in schizophrenic patients. These include deficits in tests of distractibility (Oltmanns and Neale 1975), dichotic listening (Straube and Germer 1979), the continuous performance task (CPT) (Wohlberg and Kornetsky 1973), skin conductance orienting response (SCOR) (Spohn and Patterson 1979), startle response habituation (Geyer and Braff 1982), smooth pursuit eye movements (SPEM) (Holzman, Levy, and Proctor 1979), conventional cortical ERPs (Shagass 1976), and other measures (see Braff 1985). All these experiments reveal deficits in the ability of schizophrenic patients to maintain normal attentional and information-processing functions. These results are compatible with the idea that the information-processing deficit accrues in schizophrenia from an inability to process stimuli serially. None of these approaches are as time-specific as are the visual masking, ERP, $P_{50}$, and ASR studies cited above, but future research may well examine the interrelationships of these attention-dependent measures in schizophrenic patients. We may also see the effects of increasing dopaminergic tone and of using antipsychotic medications on the information-processing performance of schizophrenic patients.

**Summary**

In sum, the viability of an information-processing approach to schizophrenia and psychotic illnesses is supported by numerous interlocking studies, such as those involving visual masking. While a complete model has yet to be developed, the information-processing perspective provides a way of conceptualizing trait/state and other major theoretical formulations of the psychological and neurobiological deficits in the group of schizophrenias and related psychotic states.

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Videotapes on Schizophrenia Available

The Video Center of the George Warren Brown School of Social Work, in cooperation with several community and mental health organizations, has produced four videotapes on the following topics relating to survival issues for chronically mentally ill persons and their families in the community.

Coping With a Chronically Mentally Ill Relative in the Community—The two videotapes on this topic were produced in cooperation with the Alliance for the Mentally Ill, St. Louis Chapter. Each videotape presents the experiences of a family which has had some success surviving the multiple problems arising from caring for a mentally ill relative in the community. The videotapes are intended for an audience of parents and relatives of chronically mentally ill persons who could benefit from a vicarious sharing of experiences with the families on the videotapes.

Psychosocial Rehabilitation: Two Agencies Based on the Fountain House Model—These two videotapes were produced in cooperation with the Missouri Department of Mental Health, Independence Center, and Places for People, St. Louis, MO. Each videotape presents a psychosocial rehabilitation agency from the point of view of its members. The tapes are intended for professional audiences as well as for families and mentally ill persons who could benefit from knowing what it’s like to experience psychosocial rehabilitation “from the inside.”

For more information about the rental or purchase of these videotapes, please contact: Dr. David Katz, Video Center, Box 1196, Washington University, St. Louis, MO 63130.