INFORMATION PROCESSING IN PSYCHOPATHOLOGY*

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Over the centuries, clinical and phenomenological observations in psychopathology have created a literature that is fascinating but difficult to quantify scientifically. Since the deviations due to psychopathology are not consistent across individuals, nor even within the same individual, conclusions based on this literature are not dependable.

Beginning with the work of Kraepelin, psychological and physiological experimentation has gradually spread to psychopathology. At first this approach was overshadowed by psychoanalysis, which reigned supreme after World War I, but was not amenable to experimentation and measurement. After World War II the emphasis in clinical psychology shifted to projective and cognitive techniques. The experimental approaches to psychopathology, however, continued at the New York State Psychiatric Institute and the Worcester State Hospital in Massachusetts. The few experimentally-oriented psychopathologists readily seized on new developments in experimental psychology, such as reaction time measurement, sensory thresholds, constancy phenomena, sensory resolution (flicker), fatigue measures, and autokinetic effects. The clinic in turn challenged experimental psychologists with new avenues for investigation: brain function in brain-damaged cases, retrograde amnesia, registration of memory, loss of familiarity (jamais vu), and false familiarity (déjà vu).

Through the interaction between clinic and laboratory, several clinically beliefs were eventually corrected or disproved. For example, early experimental evidence of perceptual distortions in schizophrenics had led to the assumption that their sensory thresholds differed from those of normals. New measurement techniques reopened the threshold question. It was found that sensory, perceptual, and cognitive behavior in such patients was not always deviant. Improved diagnosis and the introduction of signal-detection and forced-choice methods led to new understanding of
sensory, perceptual, and cognitive functioning in the mentally ill. In recent years, perhaps the most promising development in experimental psychopathology has been the rapid rise of the field of information processing. The purpose of information processing, as applied to behavior in general and psychopathology in particular, is to understand how the senses transform external stimuli into responses. Common to all such processing approaches is an emphasis, either explicit or implicit, on the temporal; processing basically means change over time. Therefore, as used here, the term processing refers primarily to events that are measured in time.

By delineating the processing stages between stimulus and response, the components (processes or events) that occur at different stages can be investigated. Other endogenous components occur simultaneously (in parallel) with these stages. These parallel components, which are control processes such as attention, are related to or influence the different stages. Figure 1 illustrates in a highly simplified version one attempt to graphically portray some of the characteristics of information processing. Most investigations focus on one or a limited number of stages and control events in an effort to understand in detail what processes and events occur between stimulus and response. It is assumed that such a systematic description will yield educational, psychological, psychopathological, and even philosophical benefits.

Several scientific models have been proposed to explain the chain of events between stimulus and response, but as yet there is no all encompassing model of information processing. This paper considers such questions as, What is or might be the relationship between a systematic information-processing description of behavior and different types of psychopathology? And what are some of the primary needs and possible future directions of information-processing research, especially in relation to psychopathology?
Over 30 years ago Norbert Wiener (1948), the father of cybernetics, addressed these questions, although at the time the term information-processing was not yet in vogue. In a remarkable chapter entitled "Cybernetics and Psychopathology," Wiener raised the possibility of understanding psychopathology by relating characteristics of computers to analogous human qualities, using an understanding of computer failure to explain human disorganization. Although cautious in his speculations about machine-human analogies, Wiener strongly believed that the principles of cybernetics had potentially important applications in psychopathology. Only recently have investigators begun to follow this lead.

Currently, the relationship between information processing and psychopathology remains almost exclusively an empirical one. A large number of empirically focused, data-oriented studies have been published comparing normal and behaviorally deviant populations. Such comparisons, by themselves, are of limited value. When compared to normals, patients usually display performance deficits. These can be explained as due to lack of motivation, failure to understand instructions or inability to concentrate, etc. In short, patient performance may be worse because they perform poorly in general, not because of the specific deficit under investigation in a particular study. In recent years, this poor performance has come to be known as a generalized deficit (Chapman & Chapman, 1973). Thus, most empirical studies of this type tell us little that we do not already know (see a discussion in Kietzman, Spring & Zubin 1980).

Although there is no shortage of facts or data, the lack of a systematic framework relating psychopathology to information processing forces one to choose between the rashness of still tentative theory and the sterility of unexplained facts. In a recent assessment of event-related potential research, Sutton and Ruchkin (Note 1) remarked that too much
effort has been devoted to compiling a dictionary rather than a grammar of results. A similar situation exists with information-processing research in the field of psychopathology. To construct such a framework, basic questions about information processing itself must be asked first. Subsequently, research aimed at answering these questions can be designed and carried out.

During the last few years rapid and significant advances have been made in developing systematic models of information processing as applied to normal behavior and these have also been extended to psychopathology. In fact, chapters on information processing in several recent books (e.g., Magaro, 1980) indicate such trends within the field. Generally, however, these treatments do not provide a detailed or systematic analysis of psychopathology within an information-processing framework.

**Visual Persistence**

To illustrate systematic relationships between information processing and psychopathology we have selected the phenomenon of visual persistence, which is an early sensory component of visual perception. In all visual processes there is a chain of events beginning with the impinging stimulus and leading to sequential changes until the final response is initiated. One of the earliest components in this chain is visual persistence. There are several reasons for the choice of visual persistence as an example of information processing. First, it is the subject of a large amount of experimental research with normal subjects (Coltheart, 1980; Long, 1980). Second, there have been numerous recent studies of visual persistence in patient populations including the mentally retarded, psychiatric patients, and brain-damaged patients. Various
techniques were used in these diverse populations and despite some diversity, the results have been generally consistent, in that some patients deviate from normals and other patients in visual persistence. Such differences suggest impairments in the earliest stages of information processing.

**Visual persistence** means that the effect of a visual stimulus continues beyond its physical offset. More technically, visual persistence can be defined as an early (initial) sensory stage of information processing that is characterized by high storage capacity and rapid decay.

Numerous techniques have been used to demonstrate visual persistence. For example, Eriksen and Collins (1967) presented two brief stimuli each consisting of a random pattern of dots separated by a brief interval of darkness. If the dark time between the stimuli was brief enough, e.g., 20 msec, the two stimuli fused to form an identifiable (nonsense) syllable. If the dark interval was lengthened, it became increasingly difficult to identify the syllable, and at a long (e.g., over 100 msec) dark interval the two dot patterns never were seen as a fused, single stimulus. The explanation for this perceptual change with increased dark interval is that the visual persistence of the first stimulus continues and fuses with the perception of the second stimulus to produce the previously unseen syllable, as long as the dark interval is within a critical period of persistence.

The phenomenon of visual persistence has been given a variety of names: visual information store; iconic storage; stimulus persistence; immediate (sensory) memory; iconic persistence; iconic memory; and sensory registration. One cannot help but wonder if these names identify different phenomena. Researchers believe that equating all these phenomena may be an
oversimplification. Recent reviews on the topic (Coltheart, 1980; Long, 1980) consider the possibility that different phenomena may have been incorrectly grouped as measures of a unitary visual persistence. Coltheart (1980) distinguishes the following types of persistence: 1) neural persistence (the neural activity in the visual system evoked by the stimulus that continues after stimulus offset); 2) visible or phenomenal persistence (the stimulus continuing to be visible for some time after its offset); and 3) informational persistence (information about visual properties of the stimulus that continues to be available to an observer for some time after the stimulus offset). In a similar vein, Hawkins and Shulman (1979) propose two types of persistence, which they label Type I and type II, while Long (1979a) subdivides Hawkin's and Shulman's Type II persistence and posits three types instead.

There are strong substantive reasons for this diversity of terms and types. Research in the field utilizes a large number of experimental techniques and procedures. Long (1980) identifies five separate procedures: partial report; persistence of form; duration of stimulus (judgment of synchrony); delay of masking effect; and successive fields (or item integration). Coltheart (1980) identifies seven procedures, some of which overlap with Long's. Extensive research on visual persistence in the last 20 years (since Sperling's 1960 monograph) has relied on all of these techniques, and conclusions have been based upon results from diverse procedures. Not surprisingly, some of the conclusions have been contradictory. Controversy has arisen about the exact nature of visual persistence, the way in which various stimulus and subject parameters influence it, its physiologic substrate, and its theoretical bases.
Clinical implications. Research on visual persistence, which began with laboratory studies of highly motivated and trained normal subjects, has begun to reach the clinic in two quite different ways. In the mid-1970s investigators began to measure visual persistence in psychiatric patients, primarily schizophrenics. Studies have been conducted by Saccuzzo and colleagues (Brody, Saccuzzo & Braff, 1980; Miller, Saccuzzo & Braff, 1979; Saccuzzo & Braff, 1981; Saccuzzo, Hirt & Spencer, 1974; Saccuzzo & Miller, 1977, Note 2) and by Knight and co-workers (Knight, Sherer & Shapiro, 1977; Knight, Sherer, Putchat & Carter, 1978). Saccuzzo has focused primarily on the visual masking technique, while Knight has used the partial-report procedure (Knight et al., 1977) and the successive-field procedure (Knight et al., 1978). Both series of studies conclude that the visual persistence of at least some psychiatric patients differs from that of other patients and from normal subjects. Their general conclusions are that such dysfunctions indicate an impairment in the earliest stage of sensory information processing in these patients. Whether the impairment has to do with the duration of persistence, with slower processing, or some other factor, remains a topic for current investigation.

The second line of visual persistence research with clinical implications is that being done with elderly subjects. This research has not yet reached the clinic, but it has an important potential application for the investigation of gerontologic and geriatric populations. Further, as Saccuzzo (1977) contends, there are many similarities between research with schizophrenic and with geriatric patients, so the problems and accomplishments of both fields complement each other.

Comparisons of the visual persistence of older and younger subjects have been undertaken by Walsh and his collaborators using visual masking (Walsh, 1976; Walsh, Williams & Herzog, 1979; Walsh & Thompson, 1978) and by
Kline and his colleagues using masking and successive-field techniques (Kline & Baffa 1976, Kline & Birren, 1975; Kline & Orme-Rogers, 1978; Kline & Szaftan, 1975, Note 3). This research has led to the general conclusion that visual persistence increases with age and this fact may help to explain some of the typical changes observed in senescence (see a general discussion by Botwinick, 1978). Walsh and Thompson (1978) reported shorter persistence for older subjects, but Kline and Sheiber (1981), using the same technique, obtained the more usual finding of longer persistence for older subjects, thereby supporting the conclusion of increased persistence of stimuli in the senescent nervous system.

Clearly, visual persistence, as an example of information processing, can provide explanatory power in the field of psychopathology. Not only has the topic been subjected to extensive investigation with normal populations, but it has begun to be applied successfully to studies of psychiatric populations. Further, it has the potential of explaining salient characteristics of the aging process when applied to geriatric populations. However, the potentially broad explanatory power of this approach may be limited by some of its complexities and difficulties. These difficulties are not unique to visual persistence research; rather, they represent the types of problems common to any attempt to use information-processing techniques in psychopathology. Some of these complexities are discussed here in detail in the hope of elucidating the problems in applying information-processing procedures to the study of clinical subjects.

Basic Questions

Having summarized the empirical contributions of visual persistence research to psychopathology, we can now analyze these findings in more detail in terms of information processing. To do this, we need to trace the route that information processing takes between stimulus and response. This
perhaps can be done best by asking and attempting to answer some basic questions about information processing and psychopathology.

The basic questions can be formulated as follows: (1) Which specific component of the observed phenomenon is being investigated? (specificity); (2) What type of processing is taking place—energy processing or information processing? (type); (3) When, in the sequence between stimulus and response, is the particular component taking place? (temporal position); (4) Where in the central nervous system is the particular component of processing taking place? (localization). We shall deal with each of these questions in turn.

1. **Specificity of the component.** The question of specificity reflects the fact that information-processing investigations always are focused on a selected phenomenon—a particular stage, process, or controlling event. No single study can encompass the entire chain of events between stimulus and response. For this report, visual persistence has been chosen as the specific component for study.

Although the specificity question seems simple and straightforward, answering it is not always easy. As mentioned above, there are several terms that seem to be synonymous with visual persistence, and various techniques are used to measure persistence. As a result, several types of persistence have to be distinguished.

Another aspect of the specificity question relates to the different response characteristics of visual persistence such as latency, duration, and amplitude. The variety of possible response measures makes it important to distinguish exactly what is being measured. For example, Knight et al. (1978) ask what might be meant by deficient iconic storage in schizophrenic patients. Is the icon inadequately formed? Is it abnormal in duration, smaller in capacity, or all of these? Is some other, as yet unnamed
characteristic of persistence different for patients? To date, research in visual persistence with psychiatric patients is relatively primitive. Because of this, the emphasis has been simply on reliably determining whether patients from various diagnostic categories, differ from each other and from normals.

2. Type of processing. In any given study exactly what is being processed--energy, information, or both? If both are involved (as they usually are) what is the relative importance of each. Answers to these questions can help in classifying the processing under investigation as sensory, perceptual, or cognitive (Kietzman et al. 1980). Investigations in the sensory domain involve primarily energy processing, those in the cognitive domain involve primarily information processing, and studies in the perceptual domain may fall into either category. Some perceptual studies are more influenced by manipulating energy while others by manipulating information. To clarify the question about what is being processed, energy or information, consider the three types of visual persistence mentioned earlier: neural, phenomenal and informational (Coltheart, 1980). Each differs in the extent to which it depends on energy. In fact, one of the major distinctions between phenomenal and informational persistence in Coltheart's view is that the former can be manipulated (controlled) by energy (i.e., by variations in luminance and duration) while the latter seems invariant to energy manipulations. Thus, grouping persistence phenomena according to energy effects is an operational way of defining (and thereby categorizing) the various types of visual persistence.

Such distinctions among the types of persistence are essential when comparing patients with normals, since patients might differ in one type of persistence (for example, phenomenal) but not in other types (for example, informational). The strategy is to review the techniques used to measure
visual persistence with patients and to classify them according to their susceptibility to energy manipulations. This has already been done in research with normal subjects; both the Coltheart (1980) and Long (1980) reviews emphasize the role that energy plays in the different techniques for measuring visual persistence. Similarly, in research with elderly subjects, Walsh (1976) utilizes a distinction made by Turvey (1973) between peripheral and central visual masking effects. The distinction is based, in part, on whether energy influences the magnitude of masking. (This approach is discussed in detail below under localization.)

Finally, the "type of processing" question may help clarify some of the confusion over the large number of terms and procedures used in visual persistence. For example, Long (1980) seriously questions use of the persistence-of-form technique (called phenomenal continuity by Coltheart, 1980) as a measure of persistence because increasing energy shortens rather than lengthens persistence with this technique. Two procedures used extensively in research with patients -- the critical flicker frequency (CFF) threshold procedure, and the two-flash threshold procedure are classified by Long as persistence-of-form techniques. Both involve judgments that depend on the presence or absence of phenomenal continuity, i.e., visible persistence. However, Long considers them inappropriate measures of persistence because of their inverse relation to energy effects. Research can clarify this issue. For example, Nicotera, and coworkers (1977) administered both the CFF and the two-flash threshold procedures to the same subjects under highly comparable conditions. They found that increasing the stimulus intensity improved temporal resolution as measured by the CFF procedure, implying less persistence; the CFF rates increased as predicted by the Ferry-Porter law. However, increased stimulus intensity had no effect upon the two-flash threshold. Taken together, these
results suggest that the two procedures may measure different phenomena and therefore are not comparable measures of visual persistence. Further, it suggests that even by Long's restrictive criteria, the two-flash threshold technique is an acceptable way of measuring visual persistence. Thus, numerous two-flash threshold studies of psychiatric patients (e.g., Gruzelier & Venables, 1975) can be included when evaluating the changes in visual persistence demonstrated by psychiatric subjects.

**Temporal position of the component.** The temporal position of visual persistence in the processing chain involves at least two aspects - ordinal location in time and other temporal characteristics such as latency and duration. In this report, the focus will be on the ordinal position of visual persistence.

In visual persistence research with patients there is general agreement that a dysfunction in persistence could indicate a very early processing impairment (Kline & Orme-Rogers, 1978; Saccuzzo & Braff, 1981). Several investigators have questioned whether the impairment is pre- or post-iconic, or whether it reflects some difficulty in the icon processing itself (Spaulding, Rosenzweig, Huntzinger, Cromwell, Briggs & Hayes, 1980).

**Localization of the component.** This question refers to the neuropsychological or psychophysiological locus of the component under consideration. This approach has no recourse to actual psychophysiological measurement but uses selected behavioral measures that are particularly indicative of location in the nervous system.

Localization can be investigated in at least two ways: in terms of **level** or **laterality**. Since behavioral events have psychophysiological correlates **throughout** the nervous system, it is not possible, at least using
only behavioral techniques, to obtain precise and clearly limited answers to the localization question. Instead, the proposed strategies involve finding more global answers. For example, the level approach distinguishes between peripheral and central levels of function. Peripheral level refers to psychophysiological correlates of behavior that develop relatively early and involve collateral rather than central (cortical) processing. In vision, for example, processes that can be explained largely by retinal phenomena, whether photochemical and/or neuoretinal, would be considered peripheral. In comparison, phenomena that obviously require higher cortical centers for processing can be considered central.

There are two ways, one methodological and one theoretical, in which this distinction between peripheral and central levels can be implemented. The most straightforward way to test for a distinction between the levels is with the dichoptic stimulation technique in which corresponding retinal areas of the two eyes are stimulated by spatially separated but otherwise physically identical stimuli. By the use of prisms, the two stimuli (each seen by only one eye) are fused so that the subject sees only one composite stimulus and has no cues as to which part of that stimulus is associated with each eye. Because of the anatomy of the visual system, dichoptic stimulation results in effects that are necessarily retro-chiasmal, i.e., at least at the level of the lateral geniculate, and therefore relatively more central. To determine whether a particular phenomenon is peripheral or central requires experiments that compare results of dichoptic stimulation with binocular (and sometimes monocular) stimulation. If results between the two (or three) conditions are highly similar, then the resulting effects are believed to be primarily central. If the results of dichoptic stimulation differ markedly from those of binocular stimulation, especially if the phenomenon (e.g., masking) is markedly reduced or eliminated, the
phenomenon is considered peripheral. It should be noted, however, that Long (1979b) recently argued against this interpretation of dichoptically-obtained data.

Turvey (1973) has developed a theoretical model of visual information processing that may be useful in identifying the level of a component. The model predicts different quantitative results for central and for peripheral visual masking. The two types of quantitative results could be tested by relating the interstimulus interval to the energy or duration of the target stimulus. In peripheral masking the product of the target stimulus energy and the critical interstimulus interval (minimum interval required to avoid masking) is a constant (TE x ISI = $K_1$). In central masking, the target stimulus duration plus the critical interstimulus interval is a constant (TD + ISI = $K_2$). To determine whether visual masking is peripheral or central, one merely decides which quantitative relation, the additive or multiplicative best fits the data. Once again, it appears that stimulus energy is an important variable to consider in obtaining a better understanding of visual persistence.

Walsh (1976) used Turvey's (1973) dichoptic masking paradigms to explore how age affects visual masking. He found processing to be slower in older subjects than in younger ones. The data fit the additive relationship, implying central masking. Walsh (1976) pointed out that the different results obtained by other investigators might mean that they were investigating peripheral rather than central masking. In their investigations of schizophrenia, Saccuzzo and his co-workers (Saccuzzo et al., 1974; Saccuzzo & Miller, 1977) interpreted their data as peripheral masking, but it is not known if they were in fact studying peripheral or central masking. It would be interesting to determine whether their data displayed the multiplicative relationship associated with peripheral masking.
in Turvey's model. Such distinctions and the methodology and theories associated with them illustrate the potential power of information-processing research.

It also is possible to approach the localization question using the laterality procedure which involves a different strategy. Recent research indicates renewed interest in the possibility of asymmetric function (functional lateralization) in the two cerebral hemispheres (Kinsbourne, 1978; Milner, 1975). Evidence from clinical studies in neurologically lesioned or commissurectomized (split-brain) patients suggests that the left hemisphere is specialized primarily for analytic, sequential, and verbal processing while the right is specialized mainly for holistic, spatial, and nonverbal processing. In normal individuals and patients without known neurological problems, both hemispheres would be functioning simultaneously to some degree and such hemispheric specialization would be relative rather than absolute. Normally, stimuli project to both hemispheres, and are processed by both hemispheres.

Investigating laterality of function is a complex matter. A number of organismic and experimental factors are known to modify the overly simple description of asymmetric functioning outlined above. In behavioral vision studies the most common technique is to briefly present visual stimuli to the right or the left of a fixation target. Stimuli presented to the right of fixation (the right visual field) are known to project directly to the left hemisphere, whereas stimuli presented to the left of fixation (the left visual field) project directly to the right hemisphere.

A laterality study of visual persistence (iconic recognition) with Korsakoff patients, alcoholic subjects, and normal controls has been reported by Oscar-Berman, Goodglass, and Cherlow (1973). Words and patterned target stimuli were presented monocularly to the lateral visual
fields. The subjects then were tested in a backward visual masking paradigm in which the same (target) stimuli were used to determine the interstimulus interval (the critical interval) needed to escape the masking effect in each lateral field. The critical interval was shorter in the right visual field for both the words and the patterns, leading these investigators to conclude that the dominant hemisphere (the left hemisphere) is more efficient in the early (iconic) stage of processing.

**Visual Persistence and Psychopathology: Illustrative Data**

The emphasis of this discussion about problems in the application of information processing to psychopathology is limited to schizophrenia, which is the clinical group most studied in persistence research. Current research in visual persistence and psychopathology, and the authors' reservations about the conclusions drawn from such research, are illustrated in a recently published study (Spaulding & colleagues, 1980). This study of visual persistence (named visual pattern integration by Spaulding et al.) used the successive-field procedure introduced by Eriksen and Collins (1967) in work with normal subjects. Spaulding et al. compared the performance of schizophrenic and nonschizophrenic groups of patients and two groups of control subjects. The only significant difference was between the schizophrenic patients and the college students, with the schizophrenics performing worse than the college students, a typical generalized deficit type of outcome. The observed difference was, therefore, not interpreted by these investigators as reflecting a basic difference between schizophrenics and normals in icon processing, at least as measured by the successive-form procedure. The authors conclude, "At present, the abnormal psychology literature can only point to post-iconic processing as the first level of cognition at which deficits that have clear implications for later processing can be detected" (p. 642).
From the above quotation, one might easily conclude that visual persistence is not impaired in schizophrenics. There are several reasons why such a conclusion seems premature. First, several other studies using techniques and procedures regarded as measuring visual persistence have shown that schizophrenic patients do differ from other patients and from normals. For example, using a modified partial-report procedure, Knight et al. (1977) found that middle-inclusive and underinclusive schizophrenics were significantly inferior in iconic imagery to an overinclusive schizophrenic group and a normal control group. In several studies using the visual masking technique, Saccuzzo and his co-workers found impaired masking in a variety of patient groups, including several schizophrenic groups. Sacuzzo and his colleagues concluded (Miller et al. 1979) that there is "growing evidence of an early information disturbance in schizophrenia that is trait dependent and is not an artifact of nonspecific pathological disturbance" (p. 446).

Others have reported visual masking differences. Steronko and Woods (1978) reported significant differences between nonpsychotic schizotypic individuals (college students whose MMPIs indicated schizophrenic tendencies) and other control groups, using a backward visual masking task. Mention has been made of several two-flash threshold studies (Gruzelier & Velmans, 1975), another procedure for measuring some aspect of visual persistence. In these studies certain types of schizophrenics displayed patterns of correlation in selected electrodermal autonomic measures that differed from those shown by other schizophrenics and by normal subjects.

Results of other investigations also suggest that early sensory processing may be different for some psychiatric patients. Collins, Kietzman, Sutton, and Shapiro (1978) reported differences in temporal
integration (a type of persistence) as measured by the simple reaction times of schizophrenic and nonschizophrenic patients. Schizophrenics showed shorter durations of complete integration, implying less persistence. The outcome for this study was unique because it indicated that the schizophrenic patients were doing something that the normals could not do under the most optimal conditions. The "better performance" outcome is the strongest rebuttal to the ubiquitous generalized deficit problem, since it is impossible to attribute the superiority of patients (compared to the normals) as due to a generalized deficit.

Although repeated laboratory testing under apparently comparable conditions failed to replicate the original Collins et al. (1978) results (Berenhaus et al. Note 4), data from a recent investigation of auditory temporal integration with patients are relevant to the issue of temporal integration in psychopathology. Using a detection threshold measure and comparing schizophrenics, depressives, and normal controls, Babkoff, Sutton, Zubin and Har-Even (1980) reported that the slope of the auditory temporal integration curve differed for the three groups of subjects, with hallucinating schizophrenics showing the steepest slope. This auditory finding was related by Babkoff et al. (1980) to the visual temporal integration experiment by analyzing a previously unanalyzed set of Collins' reaction time data. Taken together, the results of both studies leave open the possibility that schizophrenics differ from normals in at least some aspects of temporal integration.

This brief summary of visual persistence suggests that some psychiatric patients display persistence differences. Thus, it is important to evaluate carefully the two patient studies that did not show patient-normal differences in persistence (Knight et al., 1978; Spaulding et al., 1980). Both investigations used a version of the Eriksen and Collins' (1967)
successive-field technique. No differences were found between the various patient groups and the normal controls, leading these investigators to conclude that icon processing in schizophrenics is intact.

To help clarify why there are discrepancies in the persistence data of psychiatric patients, we turn briefly to research on visual persistence in the elderly. For some time researchers in that field have postulated that older people show increased persistence (Botwinick, 1978). Investigations of the elderly use many of the familiar persistence techniques such as masking (Kline & Birren, 1975; Kline & Szaftan, 1975; Walsh, 1976; Walsh & Thompson, 1978; Walsh et al., 1979) and successive fields (Kline & Baffa, 1976; Kline & Orme-Rogers, 1978). Presumably, this research with the elderly could be compared with similar schizophrenic research, but this does not seem to have happened. Thus, the Kline and Baffa study (1976), which failed to find stimulus persistence in a word-identification task (using the successive-field procedure) with dot stimuli similar to those used by Spaulding et al. (1980) apparently was unknown to the latter. Kline and Baffa could not explain why they failed to demonstrate a persistence difference with the successive-field technique. They suggested that older subjects might have had difficulty organizing the dot stimuli and that this could have interfered with the assessment of persistence. However, in a subsequent experiment using line stimuli rather than dot stimuli presented successively, Kline and Orme-Rogers (1978) demonstrated significantly greater persistence and consequently superior visual performance in older subjects compared to the younger subjects. This study has two important implications for schizophrenic research: (1) it demonstrates that the measurement of differences in persistence requires appropriate techniques; and (2) it illustrates that patients can demonstrate a better performance, a result which overcomes the generalized-deficit argument; a better
performance outcome considerably strengthens the final conclusions.

With respect to the existing persistence research with schizophrenics, the combined research of both Kline and Baffa (1976) and Kline and Orme-Rogers (1978) with the elderly reopens the question of whether some schizophrenic patients can be shown to differ in persistence if the proper techniques were employed. In this regard, the Spaulding et al. (1980) experiment on schizophrenics might be repeated using line instead of dot stimuli.

Apparently, Knight et al. (1978) did the needed research. In their experiment they used line stimuli and still found no difference in persistence between normals and schizophrenics. However, the very fact that they obtained no difference between patients and normals is worthy of comment. The usual and expected finding in such research is that schizophrenic patients perform worse than normals, if only because of the generalized deficit factor. In the Knight et al. experiment, why was no generalized deficit displayed by the patients? Were these patients only mildly ill? Did these patients actually differ in visual persistence (showed superior performance because of their longer persistence, as the elderly did in the Kline and Orme-Rogers study), but the difference was neutralized by a general deficit in their performance? Admittedly, this possibility is highly speculative, and yet the fact that several other studies using different techniques have shown patient impairments in visual persistence suggests that the successive-field technique as a tool for investigating visual persistence in psychopathology should not yet be retired. It would be interesting to do an experiment in which several tasks are included, some that measure persistence and some that do not. If the failure to demonstrate a difference in visual persistence (as in the Knight et al. study), is due to a balance between an actual persistence difference
and a generalized deficit for the patients, then one might expect the
persistence tasks to show little or no difference between the groups while
the other, nonpersistence tasks, would show worsened performance by the
patients due to their generalized deficit.

Summary and Conclusions

The purpose of this report was to survey the field of information
processing with a view towards its application to the field of
psychopathology. Just as in the normative field, no overall framework has
yet been developed for encompassing the findings. Such a framework is sorely
needed.

Information processing holds great promise for understanding
psychopathology because it can remove many obstacles that prevent progress
in the field of psychopathology. These obstacles include such factors as
the generalized deficit problem that characterizes most patient behavior,
and the well known principle that the same response to given stimuli and
stimulus situations may be arrived at by different routes. The last problem
may result in a failure to detect differences even when they exist, or may
produce differences even when the underlying processes remain intact.
Information processing, by attempting to track the actual processes in
arriving at the response, and by examining each of the components of the
different processes, promises to provide a monitoring system capable of
detecting deviations in the pathway from receptor to effector that now go
undetected.

Another difficulty is the fact that the life experience of some
patients is so essentially different from that of the normal controls that
their information-processing characteristics may be modified in ways that do
not occur in normals. (This may be an artifact due to life experience
rather than an actual characteristic of schizophrenia.)

Differences introduced by life experience may be reduced by using research techniques with schizophrenics that are extremely simple and which allow as few subject-response options as possible. For this reason we have emphasized techniques that measure responses made within the first 1,000 msec following stimulation (Zubin & Kietzman, 1966). Such immediate responses seem less dependent on speech and communicative ability, both of which may reflect some of the happenstance of life experience rather than a disorder.

As for the usefulness of information processing, it may enable patients to be classified more homogeneously by grouping them according to information-processing characteristics. This strategy could provide more objective criteria for diagnosis and for selecting better comparison groups in further experimentation. In addition, the monitoring of information processing may not only indicate where and how deviations occur, but may also provide points of entry for therapeutic intervention. Such an intervention could involve attempts to rectify such deviations or provide ways to circumvent them. Furthermore, rehabilitation of disabled individuals may be undertaken more rationally if the actual cause of the difficulty is identified.

Not all deviations in information processing necessarily lead to disordered behavior. However, some of these deviations may serve as markers for identifying individuals who under certain circumstances have a higher risk of developing episodes of psychopathology. This issue has been discussed elsewhere (Zubin & Steinhauer, 1981). Furthermore, some of these deviations may serve as earmarks of the beginning and end of episodes.

As for the future of information processing as a paradigm for research in psychopathology, it will depend on the trends in both fields. It is clear
that information processing itself has captured the attention and
imagination of cognitive psychologists in the 80's. Much of the work is in
the area of memory but it is starting to spread into the various other
domains ranging across the cognitive, psychomotor, perceptual, sensory and
physiological areas. At present, the least developed integration is in the
physiological domain. For the 21st century, our prediction is that the
physiological response to stimuli will serve as a carrier wave, conveying
sensory, perceptual, psychomotor and conceptual information loads. Instead
of speaking of the icon, we will probably refer to a pattern of stimulation
arising in a specific template of neurons which underlie the icon and which
can be manipulated directly to lengthen its duration or shorten it, or
improve its interconnections with other neurophysiological mechanisms.
Terms like consciousness, will, and even memory, are still to be dealt with,
but primarily by philosophers, educators, therapists and self-development
specialists, while scientific psychology will deal with the physiological
patterns underlying these concepts.

It is important at this juncture to enter a caveat that this can only
take place if non-invasive methods can be found for monitoring internal
brain functioning. That this is likely to be the case for the 21st century
is attested to by the fact that we can already trace much of the
physiological process engendered from the receptor up to the effector by
electrophysiological techniques such as event related potentials. The
difficulty at this time inheres in the fact that these electrophysiological
tracings represent the confluence of more than one process and it is
currently difficult to distinguish these processes from one another.
However, the availability of techniques such as CAT scans, PET scans,
cerebral blood flow (CBFs), magnetic approaches, and others yet to come,
should provide further possibilities for non-invasive monitoring of brain
processes.
This reductionist approach does not mean that the "psyche" is to be ruled out. Quite the contrary, as much of the psyche as can be brought across the threshold of objectivity will constitute the domain of information-processing psychology. The remainder, which still defies objectification, will have to wait until adequate methods become available.

Whether psychology will tend in the direction of humanism by providing closer relations between scientific research and everyday life problems or whether it will tend to become more abstracted from everyday life as the physical sciences tended to do is debatable. Our speculation is that psychology, like other basic sciences, will be removed further and further from the marketplace and from lay thinking and become more and more abstract, following the paradigm of physics and chemistry. Just as weight finally became abstracted from its concrete setting in daily life to an abstract "mass" measured by the ratio of force/acceleration, so will "intelligence" and "memory" become measured by their physiological substrates that have no apparent relationships to these concepts as conceived today. The contribution of scientific psychological discoveries to human affairs will continue in the same way that the physical sciences contribute to engineering.

As for psychopathology, it too will undergo a tremendous paradigmatic revolution. Instead of classifying individuals according to categories of disorder, they will be classified in accordance with their vulnerability to a disorder, even before an episode develops. This will be accomplished after specific markers for each disorder are discovered. By identifying the specific vulnerabilities of a person and after noting the specific environmental contingencies which tend to elicit an episode of this disorder, an educational program for avoiding the triggering of episodes, even the initial episode, will become possible. Here again, the basic
scientific markers for identifying the specific vulnerability and for determining the beginning and end of episodes will be drawn from the entire gamut of scientific models of etiology via the ecological, developmental, learning, genetic, internal-environmental and neurophysiological models. The main thrust of the 21st century will be to describe as far as possible the interactions between the components of each of these models and their relation to the physiological correlates of behavior. The preventive work will fall largely into the hands of humanists and therapists, who will work side by side with the scientists. Thus, the 21st century will see the dawn of a new era in which scientific psychology, though becoming more abstract and removed from everyday life, will lay the basic foundation for preventing and ameliorating the disorders imposed on mankind by psychopathology.
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FOOTNOTE

1. It is of interest to note that Titchener, in formulating his system of Structuralism (Heidbreder, 1933), also asked what he considered to be basic questions similar to those we ask with respect to information processing: Titchener's basic questions were: What? How? and Why?. His what and how questions described phenomena through analysis while his why question led to explanation through synthesis. Although the meanings of his questions differ slightly from ours, the idea that his system was formulated by asking selected questions, similar to what we are asking, is an intriguing one. We replace Titchener's why question with two other questions, where and when, and we add, for reasons to be explained, an initial question as well, which?

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Figure 1. An information-processing model illustrates the more important stages, storages, processes, and channels (Haber and Herschenson, 1980).