the "new look" in studies of schizophrenic attention and information processing

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Gone are the days when a researcher concerned with information processing in schizophrenia could gain a thorough understanding of the topic by merely reading the literature from his own discipline. In investigations of schizophrenic attention dysfunction it is rare nowadays to discover a clinician who finds the phenomenon adequately explained by faulty ego mechanisms, a neurophysiologist who invokes a simple disturbance in brain functioning, or a psychologist who relies on a single sure-fire test of attention. The "new look" in attention and information processing in schizophrenia reflects a burgeoning of cross-disciplinary research. At the interface between psychological research and clinical psychiatry, findings of differences between patients and normals are being applied to investigate high risk populations, to search for prognostic indicators, to shed light on clinical symptomatology, and to understand the sites and mechanisms of drug action. By applying biological and psychological techniques, researchers are studying the psychophysiological, biochemical, and neuroanatomical substrates of attention dysfunction. These were some of the topics discussed by participants in the Conference on Attention and Information Processing sponsored in May 1976 by the Scottish Rite Schizophrenia Research Program.

Schizophrenic Language

Disturbances of thought and speech are among the most dramatic clinical signs of schizophrenic psychopathology. Schizophrenic language can provide a naturalistic context in which to observe and classify disturbances of information processing. Conversely, the type and extent of language disorders in schizophrenic patients may reflect the influence of specific types of attention dysfunction.

Singer described a coding system to observe attentional deviances that may manifest themselves in overt speech. Several forms of attentional hangups and breaks have been noted among the families of schizophrenic patients, and members of a family often display similar attentional styles. In some cases, speakers seem to have difficulty moving forward in their thinking because no ideas are forthcoming, or because one idea or clause is rapidly and frequently repeated. In other cases, continuity of discourse is fragmented by breaks in the attentional focus as the speaker verbalizes distracting associations.

Cohen has investigated schizophrenic communication by asking speakers to describe a color so that a listener can select it from a display containing the referent and other nonreferent colors. Because schizophrenics perform as well as normals in the listener role, Cohen infers that patients sample their color descriptions from a culturally common pool of associations. The schizophrenic's deficiencies in the speaker role seem to reflect difficulties in editing out or ignoring inappropriate, uninformative descriptions. Chronic patients conform well to the model of the "impulsive speaker" who fails to edit
and consider the listener’s plight. Their responses are rapid and terse, rarely going beyond a simple color name. In contrast, as the color displays increase in similarity, acute schizophrenic speakers show even greater than normal increases in response latency and utterance length. The acute speaker’s communication inaccuracy seems to reflect a tendency to become embroiled in perseverative chaining. Responses that have already been rejected as inappropriate continue to be resampled until a chain of new associations is addressed to the utterance itself rather than to the color. For example, after perseverating on the description “orange,” the speaker begins to talk about vitamin C. Thus, it appears that the acute schizophrenic speaker struggles actively but unsuccessfully to stop perseverating and to edit out inappropriate responses. The chronic patient has adopted a shortcut solution: he does not edit, but rather samples and utters only a dominant response.

Rochester’s research supports a conclusion that would have been unthinkable only a decade ago: the acute schizophrenic speaker or listener is, for the most part, an adequate user of language. Schizophrenic speakers form syntactically adequate clauses and use a generally familiar lexicon. Most failures to communicate derive from thought-disordered acute schizophrenic speakers. Nonthought-disordered acute schizophrenic speakers are largely indistinguishable from normal speakers. However, even thought-disordered patients produce only 16 to 30 percent clauses that appear disruptive to normal listeners. When the schizophrenic speaker fails to communicate verbally, Rochester proposes that it is generally because he fails to accommodate to the listener’s immediate needs. For example, the speaker fails to provide clear referents for which parts of a message are new and which have already been given, or he fails to provide cohesive links between clauses. Rochester argues that communication difficulties of this type derive from information processing disturbances rather than from linguistic incompetence. In order to meet the listener’s needs, a speaker must rapidly shift attention between the clause being produced, the immediate situation, and short-term memory for prior utterances. Because of a disturbance in the control functions permitting rapid encoding and retrieval of information from short-term memory, acute schizophrenic speakers display a disturbance in the particular language functions that demand rapid attentional shifting.

**Reaction Time**

The reaction time (RT) method holds a special place in research on the psychology of attention, having been used to study psychological processes as early as 1868 (Donders 1868). The Shakow (1962) paradigm to assess maintenance of set, as well as the Sutton and Zubin (1965) cross-modality technique to measure shifts of attention, has been widely used to study attentional processes in schizophrenic patients. RT procedures have recently been applied to investigate time-linked impairments and stages of information processing in schizophrenics. The prognostic significance of RT has also been evaluated.

Reviewing a decade of research, Sutton, Spring, and Tueting described the present state of theory and data on schizophrenics’ response to modality shift. The cross-modal RT procedure was originally designed to test Mettler’s (1955) contention that schizophrenic patients experience considerable difficulty in shifting attention from one modality to another. The basic finding has been that both acute and chronic schizophrenics’ RTs are disproportionately retarded whenever the stimulus sequence entails a shift in modality. One hypothesis to explain the modality shift finding is that a more enduring trace in the patient’s nervous system interferes with the speedy response to subsequent input in a different modality. The trace hypothesis is contradicted by the finding that cross-modal retardation does not decrease in proportion to the intertrial interval. A second explanatory hypothesis is that patients have more ipsimodal expectations than normals. The expectancy explanation is contradicted by the finding that normal subjects make a higher proportion of ipsimodal guesses than do schizophrenic patients. Moreover, the schizophrenics’ greater cross-modal retardation persists even when subjects are informed in advance about what stimulus to expect. Ironically, whereas the RT cross-modal data are not consistent with an expectancy formulation, certain evoked potential modality shift findings are explained by such an interpretation. The authors discuss the possibility that there may be two cross-modal effects—one at a trace level evident in the psychomotor task, the other at a cognitive, expectancy level reflected in the evoked potential test situation. A final hypothesis, that schizophrenic cross-modal retardation is due to generalized failure to pay attention, receives little if any support.
Steffy has reexamined the factors responsible for the pattern of RT performance that Shakow attributed to segmental set. He reviews evidence that, under certain circumstances, stimuli preceding the signal to respond may lengthen the RTs of process schizophrenics. Moreover, the degree of reaction time impairment may vary as a function of the time between the onset of the impeding stimulus and the signal to respond. In one study, "probe" stimulus trials were embedded in a standard series of trials with equal preparatory intervals (regular series). On probe trials, a background frame of X's surrounded the ready signal. For process schizophrenics, but not reactive schizophrenics or normal individuals, the probe trials resulted in a U-shaped function for RTs across preparatory intervals. A tendency toward less impairment at the 7-second preparatory interval and greater impairment at the 9-second interval was correlated with heightened severity on the Elgin Prognostic Rating Scale. Even early stimuli that are informative in nature may sometimes impede schizophrenic RT, especially at long preparatory intervals. Steffy concludes that there appear to be time-linked impairments in the information processing of process schizophrenics, and recommends further investigation of the particular early signal features that provoke this deviation.

Wishner, Stein, and Peastrel have used RT to investigate the specific stages of information processing at which dysfunctions occur in schizophrenia. Their study derives from Sternberg’s (1969) model of four additive information processing stages. Prior research has indicated that, on a memory scanning task, specific experimental manipulations affect the stages independently. Thus, an interaction between a variable such as diagnosis and a given stage-related manipulation may be interpreted to index dysfunction of a particular group at that stage. In the present study alcoholics and paranoid schizophrenics were examined on the last three stages of Sternberg’s model. Serial comparison, binary decision, and translation and organization of the response were investigated by introducing the experimental factors of memory set size, presence vs. absence of presented item from the memory set, and responses using one vs. two hands, respectively. Preliminary analyses of the RT data showed no significant interactions between the diagnostic groups and any specific stage of information processing. Only overall RT slowing significantly distinguished the schizophrenic from the alcoholic individuals. However, the authors note that their attempt to test dysfunction at the fourth stage is inconclusive, because the one vs. two hands response manipulation did not prove to be a sensitive index of the translation and organization of responses.

Using the Shakow (1962) paradigm, Zahn and Carpenter posed two questions: (1) Does RT have any short-term prognostic significance? (2) Do changes in RT performance parallel changes in clinical state? Drug-free acute schizophrenic patients were rated for psychopathology and tested on RT shortly after admission and again after 4 months of hospitalization. At initial testing the patients who were to improve after 4 months did not differ significantly from their “not to improve” counterparts on any ratings of psychopathology or on the RT features usually associated with schizophrenia (e.g., set index, RT curve slopes, preceding preparatory interval effects). The only difference between the groups was that patients who were to improve showed a faster overall RT level. Upon retesting after 4 months, the “still sick” and “well” groups differed—the “well” group showing significantly smaller set indexes, a smaller positive slope on the regular series, less negative slope on the irregular series, and less difference between slopes. Zahn and Carpenter discuss the possibility that the “typically schizophrenic” features of RT performance may be influenced by the patient’s psychiatric condition, whereas only overall RT level is affected by prognostic factors. Since recordings taken during an RT task revealed a greater physiological responsivity in the “to improve” group, it may be that a higher overall responsivity to the environment underlies the short-term prognostic effects.

New Methodologies

The development of new research strategies has been one outcome of the contemporary cross-fertilization among the various disciplines engaged in research on attention and information processing in schizophrenia. Clearly, RT, the oldest technique in this area of investigation, has been creatively applied to new analyses and new questions. New approaches have also been forthcoming, including the development of methodology from quantitative psychophysics, the use of eye movement recording techniques, and the application of procedures to avoid psychometric artifact.

Quantitative Psychophysics

Allan suggests that the study of attention dysfunction
in schizophrenics may benefit from applying the methodology and theory of quantitative psychophysics. She and Kristofferson have developed a model based on the premise that attention can be switched from one sensory channel to another only at certain equally spaced time points. In normal subjects the waiting time to switch channels is approximately 50 msec. This lag time is thought to be responsible for errors in the judgment of temporal order and for the increment added to RT by uncertainty about the modality of an upcoming stimulus. Allan proposes that these and other similar experimental procedures might fruitfully be used to study the clinical problem of information processing dysfunction in schizophrenia. She suggests that two plausible interpretations of patient deficits in shifting attention must be disentangled: (1) Schizophrenics may require a greater than normal waiting time to switch channels, and/or (2) patients may not take advantage of the earliest possible moment at which attention can be switched.

Collins et al. have also applied the principles and techniques of visual psychophysics to the study of sensory processing in psychiatric patients. Their experimental procedure involves a comparison of RTs to two brief visual stimuli of equal energy but different temporal spacing: (1) a 4-msec pulse, versus (2) a 6-msec stimulus comprised of two, 2-msec pulses separated by a 2-msec dark interval. According to Bloch's law, up to some critical duration, only total stimulus energy, not its distribution in time, determines the response. Thus, provided that the experimental stimuli do not exceed critical duration (estimated to be at least 15 to 20 msec in normal subjects), RTs to both stimuli will be identical. If, however, the 6-msec double-pulse stimulus exceeds critical duration, RTs to it will be lengthened, because not all of the energy of the second pulse will be integrated in the RT response. Comparing schizophrenic patients, nonschizophrenic psychiatric patients, and normal controls, Collins et al. found that only the schizophrenic group displayed a lengthening of RT to the 6-msec stimulus. The patients who showed the greatest RT difference between the two stimuli shared the symptom of speech disorganization, a sign of formal thought disorder. For these speech-disordered schizophrenic patients, it appears that the value of critical duration is shorter than 6-msec. In effect, the schizophrenic patients have made a psychomotor discrimination which is not possible for other subjects. Control subjects could not differentiate the two stimuli by means of psychomotor behavior or verbal report. The finding of a shorter critical duration and a reduction in integrated energy may be consistent with Yates' theory of an abnormally slow rate of information processing in schizophrenic patients.

**Eyeblink and Eye Movement Recordings**

Cancro's research is based on the hypothesis that the proportions of time spent blinking and fixating are indices of internal and external attentional deployment, respectively. This distinction is supported by earlier research demonstrating that both psychiatric patients and normal controls show a reduction in blinking during visual tasks and an increase in blinking during mental tasks. In a recent study, Cancro found that schizophrenics showed a significantly higher blink proportion and blink frequency than did normal controls. Depressed patients and normal controls did not differ significantly. Fixation time was significantly less for schizophrenics than for controls, and again controls and depressives did not differ. These data support the hypothesis that schizophrenics attend preferentially to mental over visual stimuli and assimilate less information about the environment than do normal individuals.

Holzman, Levy, and Proctor presented new data and a new theoretical interpretation of disordered smooth pursuit eye movements in schizophrenia. The phenomenon is interpreted as a dysfunction in involuntary attention in accordance with William James' (1890) distinction between involuntary or passive attention and voluntary or active attention. Subjects in the tracking task give evidence of appropriate voluntary attention by the very act of cooperating in the production of eye-tracking records. The fact that subjects are generally unaware of the quality of their performance under various task conditions suggests that additional involuntary aspects may be operating. Further, instructions intended to re-alert the subjects do not significantly reduce "velocity arrests"—i.e., the number of times that the eyes pause in pursuit of a swinging pendulum. When an additional cognitive task is superimposed on the original tracking procedure, and active, voluntary attention could presumably play a stronger role in performance, there is a partial alleviation of the tracking dysfunction. Holzman, Levy, and Proctor have confirmed that a procedure developed by Shagass, Roemer, and Amadeo (1976) (in which subjects are asked to silently read numbers on the pendulum while
tracking) leads to an enhancement of smooth pursuit. However, this enhancement lasts only as long as the additional cognitive task is present, disappearing on the next trial when the numbers are absent. Furthermore, the authors report that the number-reading task normalizes only one of the two major types of eye-tracking dysfunction: that in which saccadic shifts replace smooth pursuit. The more resistant type, characterized by small, rapid interruptions of smooth pursuit, may be more prominent in schizophrenic patients and their relatives, although this remains only an impression at this time. This second type of deviant eye tracking may reflect a failure of inhibiting, synchronizing, or integrating neurophysiological systems to control high frequency random neural firing.

Salzman, Klein, and Strauss have examined the smooth pursuit eye movements of women who had been hospitalized for functional psychiatric disorder an average of 5 years earlier. All were currently functioning in the community and in at least partial remission from severe psychiatric symptoms, as evidenced by large improvements since hospitalization in psychosis-rating and health/sickness scores. Using the pendulum-tracking procedure of Holzman, Levy, and Proctor, they found no significant relationship between consensus diagnoses of schizophrenia vs. nonschizophrenic psychiatric disorder and eye-tracking performance in these remitted patients. Correlations between eye tracking and health/sickness rating at hospitalization and at study entry, time since hospitalization, and current psychosis rating were also nonsignificant. However, the psychosis rating for the time of hospitalization did show significant relationships to both a rating of eye-tracking quality and to the number of velocity arrests in this remitted state. The psychosis rating was based on ratings of delusions, hallucinations, thinking disorder, incongruous affect, incomprehensibility, and bizarre behavior. The authors suggest that pendulum-tracking performance may index an attentional dysfunction that is a trait characteristic of an enduring vulnerability to psychosis.

Matthysse's analysis of the concept of attention is similar to that of Holzman, Levy, and Proctor in stressing the distinction between voluntary and involuntary aspects. He proposes that involuntary shifts in the focus of attention—its coupling to stimuli and to internal states—are under the control of a neural system that utilizes dopamine as a neurotransmitter. Experiments on stereo-typed behavior in animals, and analogies with other diseases in which there is a relative excess of dopaminergic transmission, suggest that such an imbalance might cause inability to withdraw attention from the stimulus or idea on which it is focused, as well as inability to deny attention to stimuli or ideas that are normally held below the threshold for awareness. Chlorpromazine and related dopamine-blocking drugs seem to have a selective effect in decreasing the intensity of attentional perseveration. Matthysse presented a quantitative analysis of tracking errors in Holzman, Levy, and Proctor's pendulum paradigm, which predicts that the probability of making an error should depend on the phase of the pendulum's motion. The exact nature of the phase-dependence may be useful in determining which aspects of the tracking process are disturbed.

Use of Matched Tasks

Chapman and Chapman (a) emphasized that most studies of schizophrenic performance require a methodological improvement in order to control for the schizophrenic patient's generalized deficit across most tasks. In order to validly measure differential deficit in schizophrenia, two or more tasks matched on true score variance are required (Chapman and Chapman [b]). Failure to match tasks may produce misleading results if schizophrenics show greater impairment on one task because of its larger true score variance rather than because of the experimental variable per se. Appropriate matching can be achieved by administering large pools of items for both tasks to a group of normal subjects of a wide range of ability. Pairs of items are then selected on the basis of equal difficulty and item-scale correlation. Applications of the matched-task design have confirmed that schizophrenics show increased susceptibility to verbal associative distraction, but have failed to find any differential deficit in their response to affect-laden material or in their recall of passages with high contextual constraint. Previous positive findings for the latter two variables are interpreted as psychometric artifacts due to the use of unmatched tasks.

Strauss distinguished between two different approaches to studying the psychology of schizophrenia. In the traditional psychometric or differential approach, laboratory tasks are treated as tests, and the overall scores of schizophrenic and nonschizophrenic persons are compared. Studies in this tradition generally demon-
strate what schizophrenics do poorly. Attention and information processing may then be invoked as trait-like constructs to explain whatever group differences are found. However, problems may be encountered in establishing the construct validity of the experimental tasks, or in inferring the true bases of group differences in performance. A different approach, in the experimental psychology tradition, may be useful for handling the validity problem. In this approach, laboratory tasks are used in information-processing experiments. Experimental manipulations of task variables are used to discover how schizophrenics do a task and why they perform deviantly. Strauss argues that theoretical understanding of information processing in schizophrenia may currently be most directly advanced by more widespread use of the experimental rather than the differential approach.

Carbotte also stressed the distinction between experiments assessing individual differences or differential deficits in ability, and those examining processes or stimulus-response relationships. She argues that the use of matched tasks is essential only for the former. When research concerns hypotheses about disruptions in certain basic normal processes, particularly within an information-processing model, Carbotte suggests that experimental tasks are often inherently at different levels of difficulty. Attempts to match on difficulty level could produce a confounding of independent variables within the information-processing paradigm. In such situations converging operations based on theoretical conceptions are recommended as an alternative to matched tasks in order to rule out competing explanations.

In response to Carbotte’s comments, Chapman and Chapman (b) assert that it is necessary to match tasks in information-processing studies whenever comparisons of schizophrenic and normal accuracy are involved. Since many information-processing models demand tasks intrinsically differing in difficulty levels, Chapman and Chapman suggest that a second independent variable (a control variable) be manipulated simultaneously with the experimental independent variable to produce equal levels of difficulty on both variables. The results will then indicate whether the experimental variable accounts for more schizophrenic deficit than the control variable. Control variables should be chosen so as to be a source of difficulty clearly separate from that of the experimental independent variable. Without such matching, Chapman and Chapman note that arbitrary choices of difficulty levels for the experimental variable may lead to results that are a statistical artifact.

Vulnerability Indicators

Techniques that have been used to detect information processing disturbances in patients who have already succumbed to schizophrenia are now being applied to a new problem—the identification of individuals who are vulnerable or at risk for schizophrenia. The populations investigated in this type of research include siblings of schizophrenics, children of schizophrenics, and monozygotic and dizygotic twins of schizophrenic patients.

Spring and Zubin are investigating whether information processing disturbances found in schizophrenic patients also characterize healthy siblings of patients. Performance characteristics shared by schizophrenics and their siblings (but not shown to any great extent by matched patient and nonpatient controls) may be promising indicators of vulnerability to schizophrenia. The test battery for this study consists of dichotic listening, cross-modal RT, communicability of verbal utterances, smooth pursuit eye movements, pupillary constriction and dilation, evoked potential, visual temporal integration, and visual and auditory thresholds. These tests were designed and assembled in accordance with several methodological maxims so as to obtain meaningful patient data. Responses required (e.g., simple fingerlift) and the number of psychological functions involved during test procedures are simple. For example, the cross-modal RT task uses only brief preparatory intervals in order to measure only the subject’s ability to shift attention apart from his capacities to sustain attention or estimate long time intervals. The same attentional phenomenon is monitored in more than one response system (e.g., psychomotor response, evoked potential, pupillary diameter). Experimental manipulations are applied to try to normalize the patient’s performance in order to determine whether the factors influencing deviant performance are understood. Tests on which patients perform better than healthy subjects have been sought in order to rule out low motivation as an explanation of patient behavior. Finally, in procedures with multiple conditions, the patient serves as his own control in order to lessen the importance of baseline differences across groups as a relevant variable. By observing which performance char-
characteristics appear in acutely ill schizophrenics, siblings of probands, and recovered patients, it should be possible to separate markers of a persistent vulnerability to schizophrenia from markers of waxing and waning episodes of schizophrenic disorder.

Erlenmeyer-Kimling suggests that if attentional disturbance leads to schizophrenia rather than being solely a symptom of this disorder, children at risk for psychiatric difficulties may show evidence of attentional dysfunction. She also describes some of the special problems encountered in administering to children tests that have been found to differentiate adult schizophrenic patients from healthy controls. Control children of normal parents have been compared with high risk 7- to 12-year-old children of parents with schizophrenia or another psychiatric disorder. On a revised form of the Continuous Performance Test (CPT), high risk children made more errors than controls under both distraction and no-distraction conditions, and also showed a significantly greater decline in performance when distraction was present. Although the new CPT was therefore a rather efficient discriminator of the two groups, its efficacy for an older group of children remains to be determined. In contrast, an attention-span test was largely ineffective in differentiating the groups of children, apparently because most of the conditions were either too hard or too easy for children in the tested age range. By inspecting the extreme low end of scores on all of the indices, it was possible to isolate a group of children (predominantly from the high risk group) whose attentional performance appeared largely ineffective in differentiating the groups of children, apparently because most of the conditions were either too hard or too easy for children in the tested age range. By inspecting the extreme low end of scores on all of the indices, it was possible to isolate a group of children (predominantly from the high risk group) whose attentional performance appeared particularly disturbed. Additional analyses are needed to determine whether this subset of children emerges as a truly vulnerable group when tested on other measures of outcome or performance.

Holzman et al. have examined the possibility that the eye-tracking dysfunctions characterizing 65 to 80 percent of schizophrenics and 45 to 50 percent of their first-degree relatives are under genetic control and may serve as a genetic indicator of vulnerability to schizophrenia. The pendulum-tracking task was administered to 11 monozygotic (MZ) and 15 dizygotic (DZ) twin pairs containing at least one schizophrenic member. Protocols were scored for good vs. poor eye tracking and for number of velocity arrests without knowledge of diagnosis, twin pairings, or zygosity. Seven of 11 MZ probands and 11 of 15 DZ probands displayed poor eye tracking, consistent with previously published rates of smooth-pursuit dysfunction in schizophrenic persons. Four of 9 nonschizophrenic MZ co-twins had poor tracking, and similarly, 9 of 15 nonschizophrenic DZ co-twins revealed deviant tracking. While the rates of poor smooth-pursuit movements are not notably different in MZ vs. DZ co-twins, the MZ pairs do tend to be more often congruent in eye-tracking quality (either both poor or both good) than the DZ pairs. Concordance for poor eye tracking was 71 percent for MZ sets and 64 percent for DZ sets—considerably higher than the concordance for clinical schizophrenia. Results congruent with genetic control were more clearly obtained for the continuous-variable number of velocity arrests. The intrapair correlations for number of velocity arrests for MZ and DZ pairs were .77 and .40, respectively, paralleling the degree of genetic association. The authors note that the small sample sizes necessitate cautious interpretation of these provocative results. The MZ-DZ ratio of pairwise concordance rates on this small sample may be explained by genetic influence or by a common environmental influence. The familial nature of the eye-tracking dysfunction is further supported by data showing that the first-degree relatives of good-tracking schizophrenics, while having more frequent deviant tracking than relatives of nonschizophrenic patients and normals, have lower rates than first-degree relatives of poor-tracking schizophrenics.

**Psychophysiology**

With normal subjects, psychophysiological techniques have been used to monitor attentional performances and levels of arousal. Such measures are now being applied to infer central states in schizophrenic patients at rest and during task performances.

Vaughan discussed methodological principles for electroencephalographic recording in the study of schizophrenia. He suggests that the theories invoking hypothetical attentional or scanning mechanisms to account for schizophrenic psychopathology are premature because there are not yet operational criteria for these processes. If used properly, electrophysiological techniques may provide the needed empirical definitions. No electrophysiologic "sign" has been identified that reliably differentiates schizophrenics from other individuals. It is more fruitful to analyze the neurophysiological concomitants of information processing. The
signal-averaging technique permits measurement of electrical activity synchronized with stimuli, responses, or any behaviorally definable stages in between. The subtraction technique consists of finding the difference in evoked potential caused by a complication of the experiment, such as requiring the subject to make a response or to attend. It is also possible to make inferences concerning activity in deep structures of the brain from the topographic pattern of potentials over the surface of the scalp. Vaughan suggested making evoked potential measurements in schizophrenic patients in the context of simple and choice RT tasks, and during linguistic and symbolic processing. He also recommended topographic analyses of cortical potentials associated with saccadic eye movements during voluntary and spontaneous scanning.

Hink and Hillyard proposed the use of event-related changes in the electroencephalogram to measure selective attention in schizophrenia. Between 90 and 160 msec after presentation of a stimulus, a negative voltage change, called the N1 wave, can be recorded from the scalp. Directing attention toward stimuli enhances the magnitude of the N1 wave. The authors also studied the P3 wave, a positive voltage change which follows stimuli with a latency of 300 to 500 msec. This wave is selectively enhanced when a stimulus is presented to which a response is to be made. For example, if a subject’s task is to count designated target syllables presented to one ear, the N1 wave evoked by all syllables heard in that ear is enhanced over the other ear, but the P3 wave is enhanced only for the target stimulus. The electrophysiological approach makes it possible to distinguish between changes in the capacity for selective attention and nonspecific changes in arousal or alertness.

Kornetsky and Orzack have examined the physiological and behavioral correlates of good vs. poor performance on the Continuous Performance Test (CPT), a measure of sustained attention. The CPT requires the subject to monitor a screen and press a button each time a certain prespecified stimulus (typically a letter) appears within a series of other stimuli from the same class. In most experiments, the exposure time is 0.1 second with a constant interstimulus interval of 1.0 second. Failure to respond to 3 or more of 50 target stimuli is defined as poor performance, since normal subjects rarely exceed this error rate. About 40 percent of chronic schizophrenics miss this many target stimuli. In a series of studies of chronic schizophrenics, poor CPT performers as compared to good performers showed significantly slower overall RT, greater interference from the preceding preparatory interval, less slow-wave sleep, and a more frequent history of mental illness in first- or second-degree relatives. For poor-CPT schizophrenics, there is also a trend for more EEG waves during CPT performance to be in the high frequency, 27 to 40 Hz range. These data support the authors’ earlier suggestion that impaired sustained attention among schizophrenic patients is related to a state of central hyperarousal which interferes with the complete registration of target stimuli.

Venables and Patterson have reported a relationship between parameters of the skin-conductance orienting response and pupillographic measurements in schizophrenic patients. Subjects whose skin-conductance responses recover quickly after repeated presentation of stimuli show more complete maximal constriction of the pupil to light as well as more complete dilation in the dark than do subjects with slow recoveries. Gruzelier has found that the skin-conductance orienting response is absent in about 50 percent of schizophrenic patients. Like the slow habituators, the nonresponders showed smaller dilations and constrictions of the pupil in response to changes in illumination. Venables and Patterson note that fast recovery and lack of habituation of skin conductance are found in monkeys with hippocampal lesions, whereas animals with amygdaloid lesions are nonresponders. Pupillary dilation and constriction reflect the balance of adrenergic and cholinergic activity in the central nervous system. The authors conjecture that hippocampal inactivity and cholinergic depletion may be related. A U-shaped curve has been found relating performance on a task requiring sustained attention to the time of maximum pupil construction. On the other hand, rapid pupil constrictors perform better than either mid or slow constrictors on a speech perception detection task. Skin conductance and pupillographic measurements may, therefore, be indicative of central states.

Gruzelier proposed that temporal and limbic structures, especially the amygdala and hippocampus, control the magnitude, recovery rate, and habituation of the orienting response. He has found that electrodermal orienting responses to nonsignal stimuli are bimodally distributed in the schizophrenic population. Approximately half of the patients do not respond and the other half give responses which are often slow to habituate.
Although in normal subjects it is known that the various measures of arousal are not correlated with each other, Gruzelier postulates that in schizophrenics the arousal state tends to be unitary. This postulate seems to hold despite the fact that some schizophrenics are hyperaroused and some are hypoaroused. Skin conductance responders are higher than nonresponders in both physiological and behavioral arousal. Manipulation of arousal by white noise or increasing the rate of stimulus presentation impairs performance of responders compared to nonresponders. This finding is consistent with the hypothesis that only the responder subgroup is hyperaroused.

**Effects of Phenothiazines**

Patient medications have often been treated as a source of error in drawing inferences from research on schizophrenic individuals. Because of the difficulty of finding and testing patients in a drug-free condition, medicated patients have comprised the majority of research samples. Consequently, it has rarely been possible to determine whether the psychological, physiological, and biological patient characteristics identified in research are the result of schizophrenia or, rather, of antischizophrenic medications. Currently this problem is receiving greater research attention. Comparisons of medicated and nonmedicated patients are now being made in order to investigate the behavioral and physiological sites of drug action.

Gruzelier has found that some schizophrenics have asymmetrical skin-conductance orienting responses, not responding on the left hand and responding with slow habituation on the right hand. Lateralized asymmetries have also been found in auditory thresholds and auditory discrimination. Chlorpromazine reduces electrodermal responses to stimuli with attentional significance but has no systematic effect on responses to nonsignal stimuli. Lateralized asymmetries in orienting responses to nonsignal stimuli and in auditory discrimination appear to be decreased by chlorpromazine. Gruzelier suggests that schizophrenia may be primarily a left hemisphere deficit. The left hemisphere dysfunction appears susceptible to influence by chlorpromazine.

Oltmanns, Ohayon, and Neale have been concerned with the effect of phenothiazines on schizophrenic distractibility. They conducted two studies using neutral and distractor digit span tasks that had previously been matched on discriminating power. When newly admitted medicated psychiatric patients were grouped on the basis of hospital-assigned diagnoses, schizophrenics did not appear to be more distractible than nonschizophrenic psychiatric patients or normal controls. However, when patients were reassigned to diagnoses based on Research Diagnostic Criteria (Spitzer, Endicott, and Robins 1975), schizophrenics—particularly those with formal thought disorder—were more impaired by the presence of distraction than either normals or other psychiatric patients. In another study, chronic, medicated hospital-diagnosed schizophrenics were found to be no more distractible than normals. When the chronic schizophrenics were retested after half had been withdrawn from medication, the drug-free group showed a significant deterioration in performance on the distraction test but no change in performance on the neutral test. Re-tested medicated chronic patients showed no change on either test. Oltmanns, Ohayon, and Neale conclude that strictly diagnosed acute schizophrenic patients are exceptionally distractible. Moreover, the relationship between distractibility and thought disorder may provide a clue to the etiology of disordered speech. For the long-term chronic schizophrenic, antipsychotic medications seem specifically to facilitate the filtering out of distracting material.

The effects of antipsychotic drug treatment on attention and information processing in chronic schizophrenics have also been investigated by Spohn et al. Patients who were able to tolerate a 6-week drug washout were clinically evaluated and tested before and during an 8-week period of assignment to drug or placebo. Normalization of performance in the drug-treated group and deterioration in the placebo group were observed in clinical ratings of dysfunctional behavior and on tests of RT, continuous performance, size estimation, and span of apprehension. Drug treatment seemed to improve the ability to maintain vigilance to relevant stimuli and to increase the rate of precognitive information processing. A lessening of fixation durations on the standard size-estimation stimulus in the medicated group suggests that psychoactive drugs also reduced the preferred level of redundancy in information processing. Heart rate and skin-conductance recordings revealed a reduction in autonomic reactivity in drug-treated patients. Whereas measures of attention-perception and arousal-activation showed considerable effects of drug treatment or withdrawal, cognitive performance as measured by tests or
by clinical ratings was not significantly affected by drugs, at least over the 8-week trial period. Spohn et al. suggest that a primary functional site of antipsychotic drug action may be the reduction of excessive autonomic reactivity. One consequence of “de-arousal” may be to reduce the patient’s defensive preference for high levels of stimulus redundancy. Psychoactive drugs may, therefore, yield a more active stimulus-seeking orientation that enhances attention and information processing.

Neurophysiological and Biochemical Approaches

Whereas the psychology of attention has been the object of intensive study for the greater part of a century, biological paradigms have been slower to mature. Several workers have considered the pharmacological manipulation of attention, and neurophysiologists have begun to offer plausible neural models of attentional processes. Nevertheless, such biological theorizing has yet to be well integrated into a cogent theory of schizophrenia. That the participants in the Scottish Rite Conference presented data ranging from the organismic to the cellular level augurs well for the possibility of a unified psychobiology of attention.

Based on the correlation between deranged attention in several neurological syndromes and in psychosis, Mesulam and Geschwind proposed that a disruption of limbic-cortical pathways may be related to affective and attentional dysfunctions in schizophrenia. In patients with focal cerebral infarctions, clinical neurologists frequently identify two types of attentional deficit. Patients with global attentional deficits show difficulties in attending to stimuli in the entire extrapersonal space, whereas other patients show an impairment in only one half of the extrapersonal space. The observation that several patients with neocortical infarcts in the right, but not left, cerebral hemisphere had attentional (as opposed to primary sensory or motor) disruptions led to the hypothesis that neocortical mechanisms in the right hemisphere are intimately involved in selective attention. Because these patients also exhibited affective disturbances usually associated with the limbic system, and because of the importance of attention to emotionally significant stimuli, it is reasonable to postulate an anatomical limbic-cortical connection. Mesulam and Geschwind reported the results of experiments in rhesus monkeys that provided evidence of such a pathway from the association neocortex, paralimbic cortex, the limbic system, and the brain stem to the inferior parietal lobe. Furthermore, neurohistochemical findings pointed to the possibility that the limbic input to the inferior parietal lobe is cholinergic. Although at first glance it is difficult to reconcile a disruption of a cholinergic pathway with current theories implicating dopamine in the pathogenesis of schizophrenia, examination of the full range of neuroanatomical connections involved is helpful. That is, the substantia innominata, from which axons project to the parietal neocortex, is innervated by the nucleus accumbens septi of the mesolimbic dopamine system. The authors emphasized the importance of further investigation of limbic-cortical connections because of the confluence of pathways related to both attentional and affective processes.

The localization of attentional mechanisms in the inferior parietal lobe was also the focus of Yin’s discussion. He described the identification of three types of neurons related to attention in Brodmann’s area 7 of the monkey. Monkeys were trained to make a behavioral response to a moving or stationary stimulus, and the activity of single neurons was recorded extracellularly. Because animals were rewarded for fixating on stimuli, the stimuli took on a motivational significance. The first type of cell identified, the visual fixation cell, fires rapidly when the animal fixates on a spot of light or a food object. These cells are neither sensory nor motor in the classical sense; increased discharge is restricted to stimuli that are “motivationally interesting.” The second class of cells located is the directionally sensitive tracking cell, activated by slowly moving objects. Yin also described a saccade cell which discharges upon saccadic eye movements directed to an object in the visual field. Again, the activity of such cells is not evoked by casual scanning of the environment, but only when the eye makes a saccade to a specific object. Yin noted that the limbic-neocortical connections described by Mesulam and Geschwind probably account for the requirement of motivational significance for activity in such attention neurons.

Buchsbaum et al. described the application of a unique sampling technique to the problem of biochemically correlates of attentional deficits. Whereas a substantial amount of research employs populations with a genetic high risk for schizophrenia, Buchsbaum’s group studied a “biochemical high risk” sample. It has been re-
ported that schizophrenic patients have decreased levels of platelet monoamine oxidase (MAO) activity compared with other groups. In order to eliminate artifactual effects due to hospitalization or treatment, 375 college students were screened for MAO activity. The performance of individuals in the top and bottom 10 percent in MAO activity was studied on two attention tasks. The first measure was the Continuous Performance Test (CPT). Numerous studies have demonstrated that schizophrenics, when compared to other groups, produce high rates of errors on the CPT. The second task was an average evoked response (AER) measure of selective attention. Plasma activity of dopamine-beta-hydroxylase (DBH), another enzyme possibly related to the pathophysiology of schizophrenia, was also measured. Individuals with low levels of MAO and DBH performed poorly on the attention tasks compared to those with high MAO and DBH levels. Buchsbaum et al. discussed these results as they relate to biochemical theories of psychosis, pointing out that patients with affective disorders may have decreases in enzyme activity and attentional function similar to those found in schizophrenia.

An appropriate animal model for attentional dysfunction in schizophrenia would represent a valuable tool for research. Stoff et al. considered the proposal that drug-induced stereotypy and disruptions of conditioned avoidance in rats may provide such a paradigm. They applied several criteria for animal models of schizophrenia to the behavioral effects of N,N-dimethyltryptamine (DMT) and beta-phenylethylamine (PEA), two potentially psychotomimetic drugs which may be synthesized in humans. PEA (when combined with an MAO inhibitor) induced stereotypy, and DMT disrupted conditioned avoidance behavior in rats. Complete tolerance to the drug effects did not develop, which is consistent with the criteria for animal models of schizophrenia. Further, under some conditions antipsychotic drugs blocked the DMT-produced disruption and PEA-induced stereotypy. Although these results are compatible with the notion that the two drug-induced behaviors are related to the behavioral defects of schizophrenia, the authors were careful to point out that several other criteria must be applied. For instance, the effects of neuroleptics should not be blocked by anticholinergic drugs. Some drug-induced behaviors may be more closely related to the motor effects than to the emotional effects of psychotomimetic drugs.

Conclusions

The Conference on Attention and Information Processing achieved a synthesis of some hypotheses, theories, and concepts that are very old and some others that are very new. The hypothesis that attention dysfunction is a central aspect of schizophrenic psychopathology is as old as the recognition of schizophrenia as a psychiatric disorder (Kraepelin 1919). The longevity of this theory probably reflects the fact that it seems impossible to account for disruptions of contact with external and internal reality as severe as those found in schizophrenia without postulating disturbances in processes as fundamental as attention and information processing. The new aspects of the work presented at the conference reflect the great increment in the amount of research devoted to information processing in schizophrenia, the excellence and ingenuity of its design and execution, and the healthiness of the interdisciplinary cross-fertilization that has germinated in this field. It is particularly encouraging to observe the use of measures of attention drawn from the theory and techniques of experimental psychology. Researchers seem to have profitably abandoned the approach of arbitrarily invoking attentional dysfunction after the fact to explain schizophrenic deficits in almost any type of task. Further progress in establishing a sample of valid measures of attention is currently of prime importance in order to enhance the utility and comparability of interdisciplinary research.

Before concluding, however, it is appropriate to pause and consider an observation made by Maher (in press). This is, that advances in the methodology of research on information processing seem currently to be outstripping the development of theory in this field. It can be argued that the validity of research on attention in schizophrenia can be only as strong as its conceptual underpinnings in an adequate theory of attention. It was pointed out above that one reason for the persistence of the theory of attentional dysfunction in schizophrenia is the plausibility and powerful explanatory value of the construct. Another reason may be the global and non-specific nature of the concept of attention, so broad that alternative theories may war among themselves without clear need for the vanquished to leave the battlefield. There will very likely be no end to this dilemma without additional effort to formulate an adequate conceptual model of attention. This is not to argue that the attentional construct should be aban-
doned, thereby discarding the baby along with the bath water. Rather, there is particular need to describe and differentiate the different subtypes or subsystems of attention (e.g., alertness, selection, fixation, shift) and to devise measuring operations specific to each process. In this way it may become possible to draw a more fine-grained map of the schizophrenic's attentional processing. In charting this terrain, it will be important to identify islands of intact functioning as well as areas of deficit; to characterize the precise differences between patients and normals in information processing strategies; and to determine the interrelationships between changes in attention and fluctuations in other aspects of schizophrenic psychopathology.

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