The Continuous Performance Test, Identical Pairs Version: II. Contrasting Attentional Profiles in Schizophrenic and Depressed Patients

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Abstract. The Continuous Performance Test-Identical Pairs version was administered to 14 schizophrenic patients, 17 depressed patients, and 28 normal controls. The task was divided into verbal and spatial stimuli, as well as no-distraction and distraction (verbal and auditory) conditions. Both patient groups displayed attentional impairments compared to normal subjects, but they differed from each other in specific profiles. Schizophrenic patients were characterized by a global impairment and a particular inability to focus on the critical stimuli, whether verbal or spatial. They also made an excess of random responses throughout the task but showed no evidence that attention declined from its initial level over time. Depressed patients did not display a global attentional deficit but did show a specific inability to attend to spatial as compared to verbal stimuli and, in particular, a confusion when the spatial stimuli were only slightly different. Performance on a secondary task in response to a change in expectation improved dramatically for depressed but not schizophrenic patients, suggesting a more efficient allocation strategy, a greater reserve of processing capacity, or more dependence on motivational factors in depressed patients. Schizophrenic and depressed patients were alike in extent of distractibility. Whereas normal controls improved with the onset of external distraction, schizophrenic and depressed patients deteriorated to an equal extent. Distractibility was thus concluded to be a correlate of acute psychiatric illness and not specific for schizophrenia.

Key Words. Schizophrenia, affective disorder, attention, vigilance, laterality.

The involvement of an attentional dysfunction in at least some forms of schizophrenia has been extensively documented in studies of schizophrenic patients and in the at-risk offspring of schizophrenic parents (e.g., Orzack and Kornetsky, 1966; Wohlberg and Kornetsky, 1973; Grunebaum et al., 1974; Asarnow et al., 1977; Nuechterlein, 1983; Cornblatt and Erlenmeyer-Kimling, 1985; Cornblatt and Marcuse, 1986; Erlenmeyer-Kimling and Cornblatt, 1987; for review, see Nuechterlein and Dawson, 1984). Yet a
number of important issues remain to be resolved in order to understand the role of attention in the etiology of schizophrenia. Most notable among these are questions about the nature of the attentional impairment involved in the illness and the extent to which such a deficit is specific to schizophrenia.

These two questions are clearly interrelated. Research with normal subjects and with psychiatric patients has indicated that attention is a multidimensional construct, involving a complex of information processing skills. A large number of these have been implicated in schizophrenia, including deficits in such functions as span of apprehension (Asarnow and MacCrimmon, 1978, 1981), short-term memory/attention span (Nachmani and Cohen, 1969; Koh and Kayton, 1974; Erlenmeyer-Kimling and Cornblatt, 1978; Cornblatt and Erlenmeyer-Kimling, 1984), distractibility (McGhie et al., 1965; Oltmanns and Neale, 1975; Oltmanns, 1982), and sustained attention (Kornetsky and Mirsky, 1966; Orzack and Kornetsky, 1966; Nuechterlein, 1983; Cornblatt and Erlenmeyer-Kimling, 1984).

Deficits in similar areas have also been detected in patients with affective disorders—for example, in span of apprehension (Strauss et al., 1987), short-term memory (Sternberg and Jarvik, 1976; Strömgren, 1977; Calev and Erwin, 1985), distractibility (Oltmanns, 1978; Harvey et al., 1986; Walker and Harvey, 1986), and ability to sustain attention on tasks requiring effortful as opposed to automatic processing (Cohen et al., 1982; Roy-Byrne et al., 1986; Tariot and Weingartner, 1986). The relationship between these information processing deficits or whether any one or combination of them has a unique pathophysiological significance for either affective disorder or schizophrenia has yet to be established.

The specificity of dysfunction for schizophrenia relative to major affective disorder is a particularly critical issue because of their overlap on such psychotic symptoms as thought disorder (e.g., Braff and Beek, 1974; Harrow and Quinlan, 1977; Andreasen and Olsen, 1982; Harrow et al., 1986). Since thought disorder has been directly associated with attentional dysfunctions (Oltmanns, 1978; Walker and Harvey, 1986; Harvey et al., 1988), such shared clinical features may indicate a common attentional impairment. However, it is difficult to assess the comparability of the attentional difficulties previously reported because the two types of patients are not typically tested in the same studies. Of the few studies that have done so, most have reported similarities in processing deficits (Caudrey et al., 1980; Calev and Irwin, 1985; Cornblatt et al., 1985; Harvey et al., 1986; Walker and Harvey, 1986; Strauss et al., 1987). In fact, the overlap between the two disorders in range and type of attentional dysfunction detected suggests that schizophrenia and affective disorder may both involve a global lowering of capacity within a limited-capacity processing system—a notion that has gained considerable prominence among schizophrenia researchers (Knight and Russell, 1978; Gjerde, 1983; Nuechterlein and Dawson, 1984) and has been proposed for depressed patients as well (Cohen et al., 1982; Roy-Byrne et al., 1986).

Thus, from an etiological perspective, it is important to establish whether the two diagnoses can be differentiated on the basis of particular attentional deficits. If one pattern of dysfunction can be identified that is specific to schizophrenia and another that is specific to affective disorders, then it may be possible to establish attentional markers of a liability for each illness as well as to derive etiological clues for both. A possible alternative finding would be that some attentional dysfunctions are unique to each diagnosis while others overlap between them. This would suggest different
etiologies but a convergence of neuropathological pathways. For example, a functional excess of dopamine (DA) in schizophrenia has been hypothesized for some years (e.g., Snyder et al., 1974; Crow et al., 1976; Carlsson, 1977; Joseph et al., 1979), whereas a dopamine deficiency has been suggested to underlie affective disorders (Halaris et al., 1975; Post et al., 1981; Roy-Byrne et al., 1986). As DA may also play an important role in regulating attention (Matthysse, 1977, 1978; Joseph et al., 1979; Newman et al., 1984), the attentional dysfunctions involved in both disorders may reflect a DA imbalance, although the cause and the direction of this imbalance may be entirely different for the two illnesses.1

In the present study, we are concerned with the nature of the attentional deficit tapped in schizophrenic and affective disorder patients and with the differences between the two patient groups. The task we are using is the Continuous Performance Test, Identical Pairs version (CPT-IP). The CPT-IP is a recently developed modification of the standard Continuous Performance Test that was originally developed by Rosvold et al. (1956) and that has been used extensively in schizophrenia research (Kornetsky and Mirsky, 1966; Orzack and Kornetsky, 1966; Wohlberg and Kornetsky, 1973; for review, see Nuechterlein and Dawson, 1984). Compared to other CPT tasks, the CPT-IP is considered to be highly attention-demanding and to tap controlled effortful processing. As such measures have been established to maximize capacity deficits, we expect the CPT-IP to highlight differential profiles among diagnostic patient groups.

In Part 1 of this series of reports (Cornblatt et al., 1988), we described the CPT-IP in detail and reported normative performance profiles for a sample of 120 subjects (60 adults and 60 adolescents from 30 families) free of psychiatric illness. On the basis of findings in this normal family study and our previous research with psychiatric patients (Cornblatt et al., 1985) and with children at risk for schizophrenia or affective disorder (e.g., Cornblatt and Erlenmeyer-Kimling, 1985; Cornblatt et al., 1989), the current report focuses on the following areas: (1) a global attentional impairment; (2) differences in verbal vs. spatial attentional processing; (3) specific error patterns; (4) evidence of differential distractibility; and (5) vigilance decrements. We are interested in identifying profiles that differentiate schizophrenic patients from those with major affective disorder and that differentiate both patient groups from normal controls.

Methods

Subjects. The CPT-IP was administered to 14 schizophrenic patients, 17 depressed patients, and 28 normal controls as part of a broader study of attention.2 All 31 psychiatric patients were

1. An argument can also be made for a connection between norepinephrine and attention (Sara, 1985) and for the involvement of a norepinephrine imbalance in both schizophrenia (Meltzer, 1987) and affective disorder (Koella, 1985).

2. In the complete study, three attentional measures were administered—the CPT-IP (described here), the Information Overload Task (Cornblatt et al., 1985), and the Attention Span Task (still under analysis). A total of 65 subjects were originally recruited, including 17 schizophrenic patients, 17 affective patients, and 31 normal controls. Of this initial study group, one schizophrenic patient was untestable on all of the experimental procedures and was dropped from the group. Two schizophrenic patients were eliminated from the CPT-IP analyses because testing difficulties led to missing data. Three normal control subjects were also eliminated two because of testing difficulties and one because of a computer malfunction. See Cornblatt et al. (1985) for additional information about the overall study.
in treatment at New York State Psychiatric Institute. and the normal subjects were paid volunteers recruited from the Institute's staff.

Patients were consecutive admissions to a psychiatric service and were diagnosed according to DSM-III (American Psychiatric Association, 1980) criteria. Diagnoses were based on social history, mental status examination, and structured interview data and were made by supervised psychiatric residents or by a clinical psychologist. Of the 14 schizophrenic patients, 8 were paranoid, 5 were undifferentiated, and 1 was disorganized. The 17 depressed patients included 11 with major depression, 2 with bipolar depression, 3 with atypical depression, and 1 with dysthymic disorder. Patients with a history of alcoholism, organic brain disease, attention deficit disorders, or other functional psychoses (e.g., paranoia) were excluded from the study. Normal subjects were screened for history of mental illness, and all subjects had to be English speaking.

Ten of the 14 schizophrenic patients and 13 of the 17 depressed patients were inpatients at the time they were tested. No significant differences were found between inpatients and outpatients on any of the performance variables in either diagnostic group. Fifty percent of the schizophrenic patients and 41% of the depressed patients were medicated when tested (with six schizophrenics receiving phenothiazines and one a butyrophenone and four of the depressed patients receiving tricyclic antidepressants, two monoamine oxidase inhibitors, and one a phenothiazine). A \( \chi^2 \) analysis indicated that the proportions of medicated patients did not differ between the two groups, and \( t \) tests showed that there were no differences between medicated and nonmedicated patients on any of the CPT-IP performance indices within either patient group.

Table 1 presents basic demographic information. Although depressed patients tended to be older than either schizophrenic patients or normal controls, differences between groups were not significant. Sex was fairly evenly distributed in the schizophrenic group but was heavily weighted toward females for both depressed and normal control subjects. One-way analysis of variance (ANOVA) indicated a significant group effect for education (\( F = 4.934, df = 2, 56; p < 0.01 \)). Post hoc comparisons between groups (Scheffé test, Bruning and Kintz, 1977) showed that normal controls were significantly better educated than depressed patients (\( p < 0.05 \)) but were not better educated than schizophrenic patients, and that the two patient groups did not differ from each other. Schizophrenic and depressed patients did not differ significantly in duration of illness or in time in hospital before testing. Schizophrenic patients were, however, significantly younger in age at the onset of their illness than were depressed patients (two-tailed \( r = -2.22, p < 0.05 \)).

**Measures.** The CPT-IP is a multidimensional CPT task that systematically varies type of stimulus, distraction, and stimulus exposure time. The test was described in detail in part I of this series (Cornblatt et al., 1988). The four conditions discussed in this report, listed in the order that they were administered, include: (1) numbers (N); (2) shapes (S); (3) numbers presented in the presence of distraction (D-N); and (4) shapes presented in the presence of distraction (D-S).

Fig. 1 presents an overview of the four CPT-IP conditions. The test was administered on an Apple II plus computer. The subject's task was to respond as fast as possible, via a fingerlift from a reaction time key, whenever two identical stimuli were presented in a row. For each condition, a series of 150 trials was continually flashed on a monitor screen, with a stimulus "on" time of 50

3. In both the present study and in the family study discussed in Part I (Cornblatt et al., 1988), two additional no-distraction conditions, #5 (numbers, long exposures) and #6 (shapes, long exposures) were also administered. In these two conditions although the interstimulus interval was kept constant at 1 sec trial (as in conditions 1-4), the stimulus exposure time was lengthened to 150 ms and the dark time between stimuli was shortened to 850 ms. Since conditions 5 and 6 were always administered at the end of the test, they did not affect performance on conditions 1-4. These two conditions will be discussed, along with the reaction time findings for this sample, in a later report. It should be noted that reaction times for all responses (i.e., correct responses, false alarms, and random commission errors) were automatically recorded during administration of all CPT-IP conditions.
Table 1 Subject characteristics

<table>
<thead>
<tr>
<th></th>
<th>Schizophrenic patients (n = 14)</th>
<th>Depressed patients (n = 17)</th>
<th>Normal controls (n = 28)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (years)</strong></td>
<td>Mean 32.71 SD 10.59</td>
<td>Mean 35.17 SD 10.09</td>
<td>Mean 31.11 SD 6.09</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td>Male 8 SD 2.80</td>
<td>Male 3 SD 2.77</td>
<td>Male 7 SD 2.94</td>
</tr>
<tr>
<td></td>
<td>Female 6 SD 3.97</td>
<td>Female 14 SD 6.02</td>
<td>Female 21 SD 6.02</td>
</tr>
<tr>
<td><strong>Education (years)</strong></td>
<td>Mean 14.00 SD 2.80</td>
<td>Mean 12.82 SD 2.77</td>
<td>Mean 15.54 SD 2.94</td>
</tr>
<tr>
<td><strong>Medication (%)</strong></td>
<td>50%</td>
<td>41%</td>
<td>—</td>
</tr>
<tr>
<td><strong>Age at onset of illness (years)</strong></td>
<td>Mean 23.71 SD 7.50</td>
<td>Mean 31.12 SD 10.45</td>
<td>—</td>
</tr>
<tr>
<td><strong>Duration of Illness (years)</strong></td>
<td>Mean 9.08 SD 7.83</td>
<td>Mean 4.14 SD 6.02</td>
<td>—</td>
</tr>
<tr>
<td><strong>Days in hospital before testing</strong></td>
<td>Mean 40.70 SD 54.12</td>
<td>Mean 35.54 SD 36.15</td>
<td>—</td>
</tr>
</tbody>
</table>

1. Inpatients only.

Fig. 1. Overview of the block structure of each of the four CPT-IP conditions analyzed in this report

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>BLOCKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUMBERS NO DISTRACTION (N)</td>
<td>BLOCKS DO NOT DIFFER</td>
</tr>
<tr>
<td>SHAPES NO DISTRACTION (S)</td>
<td></td>
</tr>
<tr>
<td>NUMBERS DISTRACTION (D-N)</td>
<td>DEG# STORY STARS</td>
</tr>
<tr>
<td>SHAPES DISTRACTION (D-S)</td>
<td>STORY STORY STARS</td>
</tr>
</tbody>
</table>

CPT-IP = Continuous Performance Test, Identical Pairs version. There were breaks of approximately 30 sec between conditions. Within conditions, there were no breaks in stimulus presentation between blocks, with each block containing 50 trials. During the 2 distraction conditions, however, the form of the distractor (i.e., auditory vs. visual) differed from block to block.
ms and a dark time between stimuli of 950 ms. For purposes of analysis, each condition was further subdivided into three blocks of 50 trials—although for the no-distraction conditions this division was arbitrary and there was no break between blocks in the actual task.

Correct responses were those made to the second of two identical stimuli presented in a row; 20% of the trials contained identical target stimuli. Two types of commission errors were possible—false alarms and random errors. False alarms were responses made to the second stimulus in a "catch trial" pair. Catch trials were those on which the stimulus presented was very similar to that of the preceding trial but was not identical to it. Random errors were responses made to any of the remaining filler trials, on which the stimuli presented shared no common features with the stimuli immediately preceding them.

The CPT-IP was divided into two types of stimuli: four-digit numbers (N) and nonsense shapes (S). The numbers are considered to be verbal stimuli that avoid the difficulties commonly associated with letter sequences, such as differences in word approximation. The nonsense shapes are complex patterns specifically designed to resist verbal labeling and are viewed as spatial stimuli. A single shape was presented on each trial, and numbers and shapes were always presented in separate conditions.

The basic numbers and shapes conditions were each presented a second time in the presence of various types of distraction (i.e., D-N and D-S are simply N and S repeated with distraction). Although the type of distraction generally shifted from block to block, there were no breaks in the basic computer task.⁴ Auditory and visual distractors were presented in the order indicated in Fig. 1. There were two types of visual distraction—degraded stimuli (D-N condition only) and stars (both D-N and D-S conditions). The stars consisted of randomly distributed asterisks that surrounded the target stimuli. In the degraded stimulus condition, the four digits making up each number overlapped so that each digit covered some portion of the one next to it, and only the rightmost digit could be seen completely. Thus, while the four-digit numbers presented in the other conditions were evenly spaced and easily identified, in the degraded condition they were ambiguous and much more difficult to read.⁵

Auditory distraction consisted of a tape-recorded soundtrack of a movie played in the background. Before the D-N condition (always the first distraction condition) was presented, subjects were told that they would hear and see things that were not related to the task and that they should not allow themselves to be distracted. After completion of the D-N condition, subjects were asked multiple-choice questions to see whether they remembered any part of the background story. Before the D-S condition, subjects were told that they would again hear the background story but that this time they should listen to it as they would again be asked questions about it. However, it was also stressed that subjects should not let listening to the story disrupt their performance on the computer task, which was described as being the more important of the two.

After each distraction condition, simple four-item multiple choice questions were asked about the content of the background story. The questions not only ensured that the subjects were actually processing the auditory distraction but also served as the secondary performance measure in a type of dual task paradigm.

**Performance Indices.** As in Part 1 of this series (Cornblatt et al., 1988), the following five major indices were used to analyze performance on the CPT: (1) "hits" or the proportion of correct responses to target trials; (2) "false alarms" or the proportion of responses to catch trials;

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4. The only exception to this was just before the blocks containing the "star" distractors. In these cases there was a short pause (for the computer to load additional memory) and a message appeared on the monitor screen reminding the subject to keep his/her finger on the reaction time key.

5. The two types of visual distraction—the stars and the overlapping numbers—were loosely adapted from the degraded CPT developed by Nuechterlein (1983). In Nuechterlein's degraded CPT, the stimuli are blurred and are surrounded by plus (++) signs and are thus perceptually quite ambiguous. Since we considered the overlapping in this study a distortion that had to be perceptually "filled in" and the stars distractors that had to be "filtered out," we decided to present the two types of distractors separately.
(3) the proportion of random errors (responses to filler trials) converted into natural logs\(^6\) and signal detection indices; (4) \(d'\) (a measure of discriminability); and (5) natural log (ln) \(\beta\) (a measure of response bias or decision criterion). Both signal detection indices were calculated as outlined by Rutschmann et al. (1977), using the signal detection computer program developed by McGowan and Appel (1977). (Note that the likelihood ratio criterion (Lx) discussed by Rutschmann et al. (1977) corresponds to ln \(\beta\) in the current analyses.)

**Analyses.** The five major performance indices—hits, false alarms, ln randoms, \(d'\) and ln \(\beta\)—were first analyzed in two preliminary sets of analyses, a 3 (diagnostic group) \(\times\) 2 (sex) \(\times\) 2 (stimulus) \(\times\) 2 (distraction) \(\times\) 3 (block) repeated measures ANOVA (BMDP, 1985b, P4V) and a 3 (diagnostic group) \(\times\) 2 (stimulus) \(\times\) 2 (distraction) \(\times\) 3 (block) repeated measures analysis of covariance (ANCOVA) with age as a covariate (BMDP, 1985a, P2V). In the first set of analyses, sex was found to have no significant main effects or interactions. Since this finding was consistent with our previous results (Cornblatt et al., 1988) and with other vigilance research (Davies and Parasuraman, 1982), sex was dropped from all subsequent analyses. In the preliminary ANCOVA, age just reached significance as a covariate for \(d'\) \((F = 5.26; df= 1, 55; p = 0.03)\) but was not significant for either ln \(\beta\) or ln randoms. Covarying for age, however, did not change any of the main effects or interactions for \(d'\). Therefore, to keep the data consistent across dependent variables, all of the results in this report were generated by 3 (diagnostic group) \(\times\) 2 (stimulus) \(\times\) 2 (distraction) \(\times\) 3 (block) repeated measures ANOVAs (BMDP, 1985b, P4V). Where indicated, data also underwent post hoc analyses (Scheffé test, Bruning and Kintz, 1977) to establish which of the comparisons accounted for the significance of a given effect.

It should be noted that in this study, \(d'\) and ln \(\beta\) are calculated from the proportion of hits and false alarms, but not from the proportion of ln randoms. To avoid redundancy, \(d'\), ln \(\beta\), and ln randoms are the focus of this article, but findings for hits and false alarms are included when they add clarity to the results.

**Results**

Results\(^8\) of the 3 (group) \(\times\) 2 (stimulus) \(\times\) 2 (distraction) \(\times\) 3 (block) repeated measures ANOVAs are summarized for \(d'\), ln \(\beta\), and ln randoms in Table 2. To be conservative, we regard as significant and discuss in detail only those effects with \(p < 0.01\).

**Group Differences.** There was a significant group main effect for ln randoms, and there were no significant group interactions. Post hoc analyses indicated that schizophrenic patients made significantly more random errors (mean ln randoms = 1.00, SD = 1.086) than either depressed patients (mean = 0.481, SD = 0.870, \(p < 0.05\)) or normal controls (mean = 0.206, SD = 0.527, \(p < 0.01\)) and that depressed patients and normal controls did not differ from each other. There were no significant differences between groups on ln \(\beta\). On \(d'\), group interacted significantly with both stimulus and distrac-

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6. The raw data for random commission errors have been transformed to make the numbers more manageable and to control for skewed distributions. The proportion of random errors for each condition was multiplied by 100, added to 1, and then converted into natural logs. This index is referred to as ln randoms.

7. All main effects and two-way interactions involving group are reported and discussed. Other two-way interactions are not included as these effects were neither noteworthy nor relevant to this article. No three-way interactions were reported because none of them were significant. Effects involving "block" were corrected using the Greenhouse-Geisser adjustment (Greenhouse and Geisser, 1959). All data are available upon request from the first author.

8. The means for main effects and interactions that are presented in the sections to follow are marginal scores generated by the repeated measures ANOVAs.
Table 2. Summary of F values from repeated measures analyses of variance for d', ln β, and ln randoms

<table>
<thead>
<tr>
<th></th>
<th>d'</th>
<th>ln β</th>
<th>ln randoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnostic group (G)</td>
<td>18.981</td>
<td>1.95</td>
<td>11.651</td>
</tr>
<tr>
<td>Blocks (B)</td>
<td>5.502</td>
<td>4.523</td>
<td>2.09</td>
</tr>
<tr>
<td>Distraction (D)</td>
<td>2.13</td>
<td>3.62</td>
<td>7.032</td>
</tr>
<tr>
<td>Stimulus (S)</td>
<td>15.081</td>
<td>0.42</td>
<td>5.543</td>
</tr>
<tr>
<td>Group × block</td>
<td>1.45</td>
<td>1.17</td>
<td>0.74</td>
</tr>
<tr>
<td>Group × distraction</td>
<td>6.602</td>
<td>2.92</td>
<td>2.71</td>
</tr>
<tr>
<td>Group × stimulus</td>
<td>5.242</td>
<td>0.21</td>
<td>1.78</td>
</tr>
</tbody>
</table>

Note. Degrees of freedom (df) for all main effects = 1, 56, except for group, in which df = 2, 55, and block, in which df = 2, 112. For group interactions, df = 2, 56, except group × block, in which df = 4, 112. The only 2-way interactions reported are those involving group. Three-way group interactions are not included because none of them were significant. In Randoms are the proportion of the total number possible converted as follows: \((\text{prop randoms} \times 100) + 1\) transformed into natural logs.

1. *p < 0.001.
2. *p < 0.01.
3. *p < 0.05.

Stimulus Effects. The significant group × stimulus interaction on d' is of particular interest in that it suggests a difference among groups in pattern of verbal-spatial processing skills. Fig. 2 presents the mean d' for numbers and for shapes separately by group.

Fig. 2. Performance as measured by d' on the verbal (numbers) vs. spatial (shapes) conditions (summed across distraction) for schizophrenic as compared to depressed and normal control subjects

Bars are mean values ± SEM.
According to post hoc analyses, there were no significant differences in d’ between numbers and shapes for either the normal controls or the schizophrenic patients, and the schizophrenic patients were clearly deficient in processing both types of stimuli when compared to either normal controls or depressed patients (p < 0.01 for all comparisons). The similarity in performance on the two types of stimuli is consistent with the findings previously reported for normal adults in the family study described in Part 1 (Cornblatt et al., 1988).

By contrast, depressed patients differed from both the normal controls and the schizophrenic patients in displaying a distinct spatial impairment. While there were no differences between depressed patients and normal controls in attention to numbers, on shapes, depressed patients performed significantly more poorly than did normal controls (p < 0.01), and they processed shapes significantly more poorly than they processed numbers (p < 0.01).

To gain a better understanding of the deficit pattern in the depressed group, the proportions of hits and false alarms entering into the calculation of d’ were also examined. With regard to proportion of hits, there was a significant group main effect ($F = 19.86; df = 2, 56; p = 0.000$), with schizophrenic patients making significantly fewer hits than either depressed patients or normal controls, but with no difference between the latter two groups. The group x stimulus interaction for hits was not significant.

Proportion of false alarms, by contrast, did not yield a significant main effect, but did show a striking group x stimulus interaction ($F = 5.28; df = 2, 56; p < 0.01$). The difference in false alarm rate per group as a function of type of stimulus is presented in Fig. 3.

**Fig. 3. Proportion of false alarms (commission errors made to “catch” trials) for verbal (numbers) vs. spatial (shapes) conditions (summed across distraction) for schizophrenic as compared to depressed and normal control subjects**

Bars are mean values ± SEM.
No differences were found between any of the groups in proportion of false alarms for numbers. For shapes, depressed patients made significantly more false alarms than either the normal controls ($p < 0.01$) or the schizophrenic patients ($p < 0.05$), with the latter two groups being similar to each other. Furthermore, while within-subject comparisons indicate that neither normal controls nor schizophrenic patients made any more false alarms to shapes than to numbers, depressed patients made significantly more false alarms to shapes than to numbers ($p < 0.01$). Since a motivational problem would be expected to affect numbers as well as shapes, the spatial deficit in the depressed patient group appears to be a true processing difficulty that results primarily from an inability to discriminate between target and "catch" pairs.

**Distraction.** The presence of external distraction significantly increased the number of random errors for all subjects (no-distraction; In random mean = 0.430, SD = 0.833; distraction: mean = 0.519, SD = 0.872), but not as a function of group. Distraction had no effect on In $\beta$. Of major interest, however, was the interaction between distraction and group on $d'$.

As shown in Fig. 4, background distraction actually improved performance for the normal controls, but led to a decline in $d'$ for both schizophrenic and depressed patients. Moreover, although they started from different base levels, the extent of the performance decrement was comparable for the two patient groups. $T$ tests of mean difference scores (i.e., no-distraction $d'$ minus distraction $d'$) per group indicated that the schizophrenic (mean difference score = 0.378, SD = 0.520) and depressed patients (mean difference score = 0.353, SD = 0.754) did not differ from each other, but that

**Fig. 4.** Performance as measured by $d'$ on no-distraction vs. distraction conditions (summed across stimuli) for schizophrenic as compared to depressed and normal control subjects

Bars are mean values ± SEM.
both groups differed significantly ($p < 0.01$) from the normal controls (mean difference score = -0.309, SD = 0.763).

It should be noted that this distraction effect appeared to be nonspecific and did not vary as a function of the type of distraction—i.e., auditory vs. visual or form of visual. This was indicated by the absence of significance in any of the relevant interactions, including block $\times$ distraction, block $\times$ distraction $\times$ group, block $\times$ stimulus $\times$ distraction, and block $\times$ stimulus $\times$ distraction $\times$ group.

**Block Effects.** Vigilance decrements were examined by studying change in performance across trial blocks of the no-distraction conditions (i.e., N and S). For these analyses, each of the three performance indices was submitted to a 3 (group) $\times$ 2 (stimulus) $\times$ 3 (block) repeated measures ANOVA. Distraction conditions (D-N and D-S) were eliminated because the shifts in type of distraction within each condition were viewed as confounding vigilance effects.

Block main effects were found only for $\ln \beta$ ($F = 5.95; df = 2, 112; p < 0.01$) and indicated that all subjects became increasingly conservative with time on task. No significant change across blocks was found for either $d'$ or $\ln$ randoms. It should be emphasized that there were no differences between groups in any vigilance dimension. That is, there were no significant block $\times$ group or block $\times$ stimulus $\times$ group interactions for $d'$, $\ln \beta$, or $\ln$ randoms.

**Secondary Task.** The proportion of questions answered correctly about the content of the movie soundtrack (i.e., the story distraction component) is considered to be an index tapping the capacity to attend to a secondary task. The D-N condition always preceded the D-S condition in this study, and subjects were not told that they would be asked questions about the story content before its presentation. Therefore, any retention of the story plot for this component (i.e., St-N) was incidental. However, for the second presentation, since subjects expected to be questioned, they were specifically instructed to listen to the story, but only to the extent that listening did not interfere with the primary CPT task. Therefore, recall measured by the D-S secondary task (i.e., St-S) can be assumed to reflect effortful processing capacity available above that required to perform the sustained attention task.

A preliminary 3 (subject group) $\times$ 2 (St-N vs. St-S) ANOVA was run on the proportion of questions answered correctly after each distraction condition. A significant group main effect was found ($F = 5.31; df = 2, 6; p < 0.01$), with normal controls, on average, answering 74% of the questions correctly across the two conditions, while schizophrenic patients answered 54% correctly and depressed patients, 59%. There was a trend ($F = 2.40; df = 2, 61; p < 0.10$) for group to interact with condition, with normal controls and depressed patients but not schizophrenic patients answering more questions correctly on the St-S as compared to the St-N task.

To examine the question of whether schizophrenic patients and depressed patients were both characterized by a comparable deficiency in processing capacity, a 2 (schizophrenic vs. depressed patients) $\times$ 2 (St-N vs. St-S) ANOVA was conducted. This was based on the assumption that the shift in task demands (i.e., expectation that questions would be asked about the story plot) should lead to a reallocation of attention, with spare processing capacity focused on the background story. Overall
performance levels were not significantly different between the two patient groups. However, the group × condition interaction was significant \( F = 4.24; df = 1, 29; p < 0.05 \) and indicated that while the depressed patients markedly improved with the change in task requirements (answering 51% of the St-N questions correctly compared to 67% correct for St-S), the schizophrenic patients displayed no similar change (with 54% correct for St-N and 51% for St-S).

**Discussion**

**Processing Profiles.** On those aspects of attention and information processing measured by the CPT-IP, schizophrenic patients displayed a global deficit across all components, while depressed patients showed evidence of a more circumscribed impairment. In both cases, the deficits displayed appear to represent a true impairment in processing capacity rather than lack of motivation or an excessively conservative response style as neither group differed from normal controls in \( \ln \beta \). A sufficient range of processing abilities was detected to derive contrasting profiles for schizophrenic and depressed patients. In addition, commonalities between the two groups also suggested that some aspects of the attentional disturbance may be characteristic of nonspecific acute illness and are thus likely to be state factors. These points are discussed in more detail in the sections to follow.

**Differences in Global Capacity.** The deficit characterizing the schizophrenic patients was both quantitatively and qualitatively more severe than that displayed by the depressed patients. Attentional performance for schizophrenic patients, as indexed by \( d' \), although significantly above chance, was nevertheless profoundly impaired relative to all other subjects and did not vary as a function of stimulus, suggesting a global dysfunction encompassing a wide range of processing abilities. Schizophrenic patients also made significantly more random errors than either normal controls or depressed patients on both types of stimuli. Overall, these findings can be interpreted as indicating that a severe global attentional deficit characterizes many schizophrenic patients. A similar global attentional impairment has also been reported for children at risk for schizophrenia (Cornblatt and Erlenmeyer-Kimling, 1985).

Depressed patients, on the other hand, displayed a pattern of processing difficulties that does not support a global processing deficit. Compared to normal subjects, depressed patients were impaired in their spatial abilities, but were significantly better than schizophrenic patients. Depressed patients were not deficient in verbal processing. Further, they did not differ from normals in rate of random errors for either type of stimuli. Thus, the depressed patients in this study do not display the diffuse loss of attention that is characteristic of the schizophrenic patients.

**Differences in Spatial vs. Verbal Processing.** The spatial disadvantage found here for the depressed patients is in keeping with similar results from a number of studies. Poor performance IQ relative to verbal IQ has been reported for depressed adults and for children at risk for bipolar illness (Kestenbaum, 1979; Sackeim and Decina, 1983). Abrams et al. (1981) found affective patients to be clearly better than schizophrenic patients on Wechsler Adult Intelligence Scale verbal scores, but to be be
much closer to the schizophrenic patients in performance IQ scores. Similarly, Deputura and Yozawitz (1984) reported that depressed patients were deficient in their recall of nonverbal relative to verbal lists. It is important in this context to point out that in comparing spatial and verbal processing, the CPT-IP has the advantage over other measures of both holding all testing procedures constant and being matched for difficulty level.

With respect to comparable difficulty levels, while the normal adults in this sample and in the family sample described in Part I (Cornblatt et al., 1988) performed slightly better on numbers than on shapes, in neither case was the difference close to being significant. As indicated in Figs. 2 and 3, the distributions of scores for the two types of stimuli are comparable and neither comes close to ceiling (see Part I for discussion about ceiling effects). Furthermore, shapes cannot be considered inherently more difficult than numbers since the adolescents tested in the family sample were significantly better on shapes than they (or the adults) were on numbers (Cornblatt et al., 1988).\(^9\) Finally, for 150 normal adults in the CPT-IP data bank who range in age from 18 to 59 years (Cornblatt, unpublished data), the discriminating power of shapes and numbers is essentially equivalent. For numbers, the combined difficulty level for all blocks is 10.82 (SD 3.56) with a reliability of 0.82; for shapes, the difficulty level is 11.42 (SD 2.99) and the reliability, 0.80. Thus, the verbal-spatial discrepancy measured by the CPT-IP is unlikely to be a function of task difficulty level or methodology, but rather is likely to be reflective of a true processing deficit.

The finding of impaired spatial processing in depressed patients is consistent with the many studies indicating that affective disorders involve a dysfunction of the right hemisphere (e.g., Flor-Henry, 1976; Goldstein et al., 1977; Taylor et al., 1979, 1981; Flor-Henry et al., 1983). By contrast, the global deficit found for schizophrenic patients in this study is at odds with the large body of literature associating schizophrenia with a left hemisphere dysfunction (e.g., Venables, 1966, 1969; Flor-Henry, 1976; Gur, 1978; Golden et al., 1981; Gur et al., 1983).

A possible explanation for this discrepancy is that schizophrenia may, in fact, involve both a left hemisphere deficit and a more diffuse attentional impairment. In the first case, higher cognitive functioning of the type associated with the left hemisphere would be affected, such as the abstract reasoning tapped by the Wisconsin Card Sorting Task studied by Weinberger et al. (1986). In the second, an abnormality in the brainstem (Mirsky, 1969, 1978; Seidman, 1983) may lead to a global attentional deficit that is detectable at a very early stage of the illness. This possibility would be compatible with Weinberger's (1987) theory of a brain lesion affecting the dorsolateral prefrontal cortex that does not become activated until late adolescence and is supported by the findings of the New York High-Risk Project (e.g., Cornblatt and Erlenmeyer-Kimling, 1985; Erlenmeyer-Kimling and Cornblatt, 1987a, 1987b; Cornblatt et al., 1989). Erlenmeyer-Kimling and Cornblatt (1987b) consistently detected a

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9. A significant spatial advantage (i.e., higher performance on shapes relative to numbers) has also been found in 42 boys, aged 7-12 years, who were diagnosed as having attention deficit disorders (Cornblatt et al., 1987). In addition, in the New York High-Risk project, a spatial advantage was displayed by subjects at high and low risk for schizophrenia both when tested on the CPT-IP for the first time in mid-adolescence (n = 109) and subsequently when retested in their late teens (n = 90) (Cornblatt and Winters, 1987).
global attentional deficit in children at risk for schizophrenia, beginning at the ages of 7-12 years, whereas no impairment on the Wisconsin Card Sorting Task was detected in any of the children when tested between the ages of 12 and 19 (Cornblatt and Erlenmeyer-Kimling, unpublished data).

Differences in Secondary Task Performances. The secondary performance indices (St-N and St-S) additionally address the issue of a generally impaired processing capacity. The change from filtering out the background story in St-N to active processing of the story in the St-S condition presumably represents a shift from incidental to effortful processing. It also represents a person's capacity to process two sources of information at the same time. It is of particular interest here that the schizophrenic patients did not show a shift in performance in keeping with their changed expectations. It should be kept in mind, however, that for both story conditions, the schizophrenic patients were able to answer about 50% of the questions accurately—well above chance level—and thus are retaining the story on some level. It is possible that schizophrenic patients are not grossly impaired in their ability to process incidental information, but do not have the reserve of capacity needed to shift into more active or effortful processing of the secondary material.

Both the depressed and normal subjects showed improvement in the proportion of questions correctly answered when they were actively attending to the background story. This suggests that depressed patients, unlike schizophrenic patients, have processing capacity available above the amount allocated automatically. These findings also suggest that motivational factors may play a more important role in reducing effortful processing for depressed patients than for schizophrenic patients—although the current findings also suggest that the spatial impairment associated with depression is a true processing deficiency that is largely independent of motivation.

Cautionary notes must be interjected, however, when interpreting the secondary task findings. First, the incidental task always preceded the one requiring effortful processing because it was only possible for subjects to be unaware of being questioned about the story the first time it was presented; it is unclear whether this fixed order influenced recall in any systematic way. Second, the St-S task was twice as long as the St-N task (i.e., St-S was presented for 100 trials whereas St-N was presented for only 50; see Fig. 1). Therefore, some of the differences between the two story conditions may be a function of their psychometric properties. We are currently in the process of investigating this possibility by comparing incidental vs. effortful processing of auditory distraction tasks of the same length.

Differences in Patterns of Errors. Surprisingly, while highly impaired in their capacity to detect target trials, the schizophrenic patients did not produce an excess of false alarms. Thus, these patients appeared to have little difficulty in screening out trials that were quite similar but not identical to each other (the "catch" trials). It is unlikely that the lowered false alarm rate was a function of a generally depressed response rate, as in addition to not differing from the other subjects in In β, the schizophrenic patients also made the most random errors.

The finding here that schizophrenic patients were specifically unable to identify "target" stimuli is consistent with self-reports in which these patients, especially in the
early stages of illness, describe themselves as being unable to focus on the critical information in their environment (McGhie and Chapman, 1961; Freedman and Chapman, 1973). In addition, the children tested in the New York High-Risk Project on the earlier playing card version of the CPT showed the same pattern of results as reported here for the adult schizophrenic patients. At ages 7-12, children at risk for schizophrenia made significantly fewer hits and more random errors than either children at risk for affective disorder or normal control children, but did not differ from either group in proportion of false alarms (Rutschmann et al., 1977; Cornblatt and Erlenmeyer-Kimling, 1985).

In comparison with the schizophrenic patients, the depressed patients were markedly impaired in their ability to filter out the "catch trials" but only on the spatial conditions. These patients had no particular difficulty in detecting identical (target) trials or in avoiding responses to the random trials, regardless of type of stimulus. Exactly why depression should involve this particular deficit is unclear, although it may represent the most difficult aspect of spatial processing in the CPT-IP task.

Differences in the rate of random errors are also of interest with respect to the differential profiles. In normal populations, this type of commission error has a very low frequency. For example, the normal family members described in Part I (Cornblatt et al., 1988) averaged a proportion of 0.0065 random errors (raw scores) across conditions, and the normal controls in this study similarly generated a mean proportion of 0.006 random errors. Because successive random trials do not share any features in common, they are the easiest trials to judge as being different from the preceding one. It is therefore unlikely that random commission errors are due to perceptual/cognitive confusions; they appear instead to represent a gross attentional lapse. The fact that only schizophrenic patients make an excessive number of these errors again supports the notion that a global impairment is characteristic of schizophrenia but not of depression.

**Similarities Between Schizophrenic and Depressed Patients.** The major commonality shared by the patient groups that distinguishes both from normal controls is their response to the presence of external distraction. The presence of the irrelevant background material acted to improve performance in the normal control group, which was also true of the subjects in the normal family sample described in Part I (Cornblatt et al., 1988). By contrast, performance declined for both schizophrenic and depressed patients in the presence of distraction. Moreover, despite baseline differences in the no-distraction performance of the two groups, the depressed patients were as disrupted by external distraction as were the schizophrenic patients. This finding is entirely consistent with the comparable decline in performance for both groups of patients with the onset of auditory distraction on the Information Overload Task previously reported by Cornblatt et al. (1985).

These results strongly suggest that differential distractibility, once thought to be the hallmark of the schizophrenic attentional deficit, is not specific to schizophrenia, but is most likely a correlate of psychosis in general. It is also possible that heightened vulnerability to distraction is not a trait with predictive potential but is primarily a state marker that is displayed by acutely disturbed patients regardless of diagnosis. This would be compatible with the inconsistent findings reported by the high-risk
studies, which have not clearly demonstrated differential distractibility in children at risk for schizophrenia (Cornblatt and Marcuse, 1986). More definitive answers about the state/trait nature of differential distractibility, however, await longitudinal studies of both schizophrenic and affective disorder patients.

**Similarities Between Both Patient Groups and Normal Controls.** Contrary to what might be expected from the literature, no differences among any of the groups were found in ability to sustain attention across time on the CPT-IP. That is, attention, as measured by d', did not show a consistent decline across trial blocks for any of the three subject groups. By contrast, all three groups showed a highly significant shift toward a more conservative response style over time. In addition, the sample as a whole showed a tendency to make fewer random errors over time ($p < 0.08$). These vigilance effects essentially replicate those reported earlier for the subjects in the family study (Cornblatt et al., 1988).

The current findings contradict the common notion that the basic dysfunction in schizophrenia is an inability to sustain attention over time. This view appears to be derived from the generally unsubstantiated assumption that a CPT of any design is a vigilance test (i.e., a task that reliably demonstrates decrements in sensitivity over time). However, most studies reporting CPT deficits in schizophrenic patients do not analyze performance changes with time on task and therefore do not address the vigilance issue. Furthermore, the few studies that have looked specifically at vigilance (e.g., Nuechterlein, 1983) have not found evidence of a differential decline in schizophrenic patients. Instead, it appears that the schizophrenic deficit is a result of a more general processing impairment (i.e., overall level of discriminability rather than discriminability decrement) that is operational from the beginning of a sufficiently demanding attentional task and that is not dependent on the task’s vigilance properties. This conclusion is especially important because it indicates that it is not necessary to subject disturbed patients to arduous vigilance tasks in order to tap attentional dysfunctions.10

**Summary of Differential Profiles.** Schizophrenic patients have the following characteristics: (1) A global attentional impairment that encompasses both verbal and nonverbal processing and that results in an inability to focus on the critical information in the environment. (2) No particular difficulty in inhibiting responses to stimuli that are subtly different from target information, although this may be a function of an inability to recognize the “catch” stimuli as near targets. (3) A distinct problem in inhibiting responses to stimuli markedly different from others; these random errors are most likely due to gross lapses in attention. (4) An inability to increase processing capacity (on a secondary task) beyond the level performed automatically.

Depressed patients typically show the following characteristics: (1) No general

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10. It should be emphasized that the point here is not that the CPT-IP is an exhaustive vigilance task, but rather that it is not necessary to administer a vigilance task at all to study the schizophrenic attentional disturbance. In fact, we have doubled the number of trials of the N and S conditions to 300 trials each in the most recent testing round of the New York High-Risk project and have found a decline in d' with time on task. As expected, however, this decrement was displayed by all of the subjects tested and subjects at risk for schizophrenia did not differ from those at risk for affective disorder or from normal controls in the extent of the decline.
lowering of attentional capacity but rather a specific inability to process spatial information. (2) Within the spatial domain, no deficit in detecting target information but a difficulty in screening out stimuli that differ only slightly from each other. (3) The capacity to increase processing in response to a change in the task demands (as indicated by improved secondary task performance), suggesting that motivation may play an important role in reducing effortful performance.

Conclusions

A specific pattern of attentional deficits can be seen to characterize schizophrenic patients. The overriding feature of this profile is an impaired capacity to process attention-demanding information in the environment—primarily a function of an inability to focus on critical information. This focussing difficulty appears to be diffuse—that is, to involve both verbal and nonverbal information—and is quite consistent with the introspective accounts offered by schizophrenic patients themselves. Schizophrenic patients also show a high rate of purely random responding, which may reflect attentional lapses on a very gross level. They are not, however, differentially affected by slight differences in stimulus features, which place demands on subtle selective attentional capacities.

Depressed patients, on the other hand, appear to have a processing difficulty specific to spatial information. The particular form of the deficit, moreover, appears to involve a difficulty in selectively attending to subtle differences between spatial stimuli. This is reflected by a very high rate of commission errors to “catch” trial pairs, on which stimuli presented in sequence differ by only a few, easily missed features. Viewed overall, the pattern of attentional impairment displayed by the depressed patients in this study is highly suggestive of a right hemisphere dysfunction and does not support the view that depressed patients show a general, nonspecific reduction in processing capacity.

Two additional conclusions from this study are the following: (1) Distractibility does not discriminate between depressed and schizophrenic patients and may, in fact, simply be a nonspecific correlate of a disturbed mental state. (2) There is no deficit in sustained attention as measured by the CPT-IP in either patient group; neither group differed from normal controls in their ability to maintain their attention over time. Thus, the pattern of deficits specific to each diagnosis is likely to be apparent from the beginning of any attentional task that is sufficiently demanding and that incorporates an adequate range of processing skills.

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