A Limiting Factor in the "Normalization" of Schizophrenic Orienting Response Dysfunction

by Alvin S. Bernstein, James A. Riedel, Joel Pava, David Schnur, and Jack Lubowsky

Abstract

Forty schizophrenic patients, 40 non-schizophrenic patients, and 40 normal subjects were given 60 each alternating 1000- and 2000-Hz, 1-second tones at 60 dB. Half of each sample, the Press Group (PG), had to press a pedal to the high (low) target tone, ignoring the nontarget tone. The other half, the Nonpress Groups (NPGs), were given no reason to attend. Skin conductance response (SCR), finger pulse volume (FPV), and electroencephalographic (EEG) activity were recorded. NPG schizophrenic subjects were more often nonresponsive in both SCR and FPV than other samples, but less often responsive in EEG only when a 20 percent criterion of alpha blockade was used. Schizophrenic subjects showed greater consistency of OR nonresponsiveness in SCR and FPV, and nonsignificantly greater consistency in criterion alpha block, pointing to a deficit in orienting response (OR) rather than in peripheral response. When the targeted signal was given, schizophrenic subjects showed the same response as other groups in all systems. This was not due to an indiscriminate increase in reactivity, since response increase centered on the targeted signal itself in all groups. As the target signal was repeated, autonomic OR in schizophrenics declined sharply so that they again became underresponsive. Thus, OR "normalization" achieved by targeting significant signals is restricted to relatively early responsiveness. The rapid decline in autonomic OR may help explain differences in schizophrenic subjects between P300 and autonomic ORs to significant stimuli. Schizophrenic subjects were no different from controls in bilateral SCR or FPV asymmetry, but displayed less frequent criterion alpha blockade and reduced background alpha power in the left hemisphere. Each system showed a different pattern of bilateral asymmetry, reflecting complex, not well understood relations among these responses. This was further emphasized by the fact that skin conductance level (SCL) incremented over trials in PG subjects, reflecting sustained activation, while EEG background showed an increase in slower wave power, consistent with reports of increased drowsiness. The only drug effect seen was a lowering of SCL. Neuroleptics were associated with a flexible inhibitory control of SCL, permitting normal-like increment when circumstances required. Depressed patients' data suggested they might show heightened OR nonresponsiveness to innocuous stimuli which might not be subject to "normalization" by manipulation of stimulus significance; hence OR deficit might still differentiate schizophrenic from depressive patients.

After long dispute, a general consensus has emerged concerning the nature of the dysfunction displayed by schizophrenic subjects in the autonomic components of the orienting response (OR). A multinational group (Bernstein et al. 1982) examined skin conductance response (SCR), the most widely studied OR component, in 14 studies in 6 laboratories in the United States, Britain, and Germany. Although these studies variously examined patients with chronic and acute schizophrenia, males and females, those receiving neuroleptic drugs and those not receiving them, and recorded SCR...
from either (or both) hands using a variety of instruments, one virtually universal finding emerged—namely, that 40-50 percent of the schizophrenic population displays nonresponsiveness when presented with innocuous stimuli of low-to-moderate intensity. Similar data have been obtained in Sweden (Alm et al. 1984). In addition, a detailed review of the literature by Ohman (1981) arrived at the same conclusion, as do more recent reviews by Dawson and Neuchterlein (1984) and Venables and Bernstein (1983).

While most of the work so far has centered on the SCR, nonresponsiveness in this subpopulation appears to generalize across autonomic OR components. For example, schizophrenic SCR nonresponders were shown to be similarly nonresponsive in the finger pulse volume (FPV) component of the OR (Bernstein et al. 1981), and to display diminished pupillary reactivity as well (Patterson and Venables 1976; Straube 1979a).

The OR is believed to reflect a call for the allocation of special stimulus-processing resources (i.e., the engagement of a high level, limited capacity central processing channel) when the individual is confronted with uncertain, potentially significant stimuli (Ohman 1979; Bernstein 1979, 1981a). Thus, the dysfunction described above suggests that a large subgroup within the schizophrenic population may be characterized by a substantial deficit in the ability to assimilate information from the environment.

Important clinical parameters of nonresponsiveness are being defined. It is displayed particularly by those schizophrenic patients who are characterized by high levels of emotional withdrawal and conceptual disorganization (Straube 1979b; Bernstein et al. 1981). Such nonresponsiveness displays a trait rather than a state character since it continues to be displayed even after clinical remission (Zahn, Carpenter, and McGlashan 1981; Iacono 1982), and is seen as well in young adults considered at risk for schizophrenia by virtue of high anhedonia scores (Simons 1981). Schneider (1982) reported that patients with chronic schizophrenia who display the least SCR OR response show poor clinical response to neuroleptics. Alm et al. (1984) found that nonresponder schizophrenic subjects tend strongly to have blood relatives who have been diagnosed schizophrenic, while responder patients tend to be the sole schizophrenic patients among their blood kin.

Bernstein (1969, 1979; Bernstein and Taylor 1979) indicated that to elicit an OR, there must be detection of stimulus uncertainty coupled with an evaluation of that stimulus as potentially significant for the observer. A sufficient degree of uncertainty is needed to warrant a call for the central channel rather than for preattentive processing (Ohman 1979), while significance is required to justify allocation of limited capacity channel space (Bernstein 1981a).

This conception raised the possibility that the schizophrenic patient's nonresponding might reflect alterations in his evaluation of stimulus significance rather than necessarily a loss of OR capability per se. Left to their own judgment, many schizophrenic patients may dismiss as irrelevant signals that most normal observers judge significant (e.g., the proffered experimental stimuli), while focusing on signals considered peripheral by normals (e.g., a smudge on the wall). As described by Kahneman (1973), such differences would have powerful impact on the allocation of limited attentional resources and therefore on the appearance of ORs to given stimuli.

This view was supported when Gruzelier and Venables (1973) and Bernstein et al. (1980) were able to bring the frequency of nonresponsiveness among schizophrenic subjects within normal limits by making explicit the significance of the experimental stimulus and requiring that the subject make a simple response to targeted signals.

Bernstein and Taylor (1976) reduced OR hyporesponsiveness among (DSM-II) adolescent schizophrenics in the same way, and also by using signals of high intrinsic significance (the human voice rather than pure tones). Demonstrations by Bernstein (1970; Bernstein et al. 1981) that the incidence of schizophrenic nonresponsiveness could be reduced by raising stimulus intensity, and by Gruzelier et al. (1981) that individual nonresponder patients could be made responders in this way offer further support.

Parallel results were obtained in conditioning studies. Ax et al. (1970) reported poor SCR conditioning in schizophrenic subjects, attributed to an inability to establish the motivational significance of the conditioned stimulus (CS+). Baer and Fuhrer (1969) reported an association between failure to condition SCR in schizophrenia and failure to detect the significance of the CS+. When patients were explicitly informed of the CS+ significance, normal conditioning appeared (Fuhrer and Baer 1970).

Such a position with regard to the meaning of OR nonresponsiveness in schizophrenia represents a shift from the earlier view which saw it as an indication that schizophrenic patients had either lost central attentional processes or were deficient in ability to receive input from the environment (Maltzman and Raskin 1965).
It now seems clear that many schizophrenic patients retain more OR-associated information-processor capability than had been assumed, and that engagement of this system may be obtained under proper instructions and stimulus conditions.

However, as the interpretation of OR nonresponding shifts from an emphasis on lost capacity to one of altered allocation decisions, some investigators have assumed that schizophrenic patients "differ from nonschizophrenics in the nature of the stimuli to which they attend and not in the actual ability to attend" (Schneider 1976, p. 167, italics added). They assume the dysfunction to be entirely a matter of allocation, with no deficit in capacity once the system has been engaged by whatever means.

Where OR research is concerned, such conclusions may be premature since the issue has not been tested. Studies so far available indicate only that instructions explicitly establishing the significance of a targeted stimulus can elicit ORs with a normal incidence in otherwise often nonresponsive schizophrenic subjects. It has not yet been determined whether these ORs display any further deficiencies once initial onset has been "normalized."

We report the first of several studies planned to explore this area. To begin with, we asked whether schizophrenic subjects would continue to display normal-like ORs to schizophrenic and nonschizophrenic psychiatric patients, and to normal controls. Subjects were required to press a pedal as quickly as possible on hearing a specified tone while ignoring the other. We compared diagnostic groups in response to each signal. We also wanted to learn whether the increased incidence of ORs elicited from schizophrenic patients by such instructions was focused on the signals explicitly targeted. It is possible that this reduction in nonresponsiveness may only be secondary to a diffusely heightened responsiveness to both relevant and irrelevant stimuli in consequence of heightened levels of arousal produced by the task instructions (Bohlin 1976).

Comparing schizophrenics with controls on the ORs elicited by explicitly significant signals and those to the alternating nonsignificant ones provides some relevant data. We enlarged upon this by adding groups that received the same alternating tones without being given any reason for attending to them. By comparing ORs to nonsignificant tones in groups required to attend to certain signals with those elicited by the uniformly nonsignificant tones of the nonpress groups, we could determine whether increase occurred to irrelevant stimuli as a consequence of their being embedded in a task demanding vigilance. Skin conductance levels (SCL) and background electroencephalographic (EEG) power were examined to assess arousal levels.

In OR studies of schizophrenia, more than one OR component must be examined in order to determine whether any dysfunction reflects deficit in the OR rather than in some peripheral response system. Further, we previously reported (Bernstein et al. 1981) a dissociation between phasic EEG response and that of SCR and FPV. This report is in need of confirmation. We therefore again recorded SCR, FPV, and EEG response. While both SCR and FPV are autonomically mediated, they have been shown to be independent indices of the OR (Furedy and Gagnon 1969; Bernstein et al. 1981).

Data were recorded from each hand for SCR and FPV, and from each hemisphere for EEG. Several authors have reported hemispheric asymmetry in EEG response among schizophrenic patients (e.g., Flor-Henry 1976; Shagass 1976). For autonomic response, the issue is less clear. While Cruzelier (1973) reported a particular deficit in left-hand SCR OR in schizophrenia, others have failed to replicate this (e.g., Patterson and Venables 1978; Bernstein et al. 1981). If bilateral asymmetry characterizes EEG but not autonomic response, it would suggest another instance of autonomic nervous system-EEG dissociation, the details of which need to be spelled out.

Both medicated and nonmedicated patients were examined. While the literature generally points to the absence of a neuroleptic effect on phasic ORs (see Venables 1975), this allowed us to continue direct testing for such effects on each of the OR variables under study.

Finally, some current work (Janes and Stroock 1982; Lacono et al. 1983) suggests that depressed patients may display an incidence of OR nonresponsiveness approaching that in schizophrenia. We therefore looked (post hoc) at the depressed patients in our nonschizophrenic patient samples for further information.

**Methods**

**Subjects.** Data are presented from 40 chronic schizophrenic patients, 40 nonschizophrenic psychiatric patients, and 40 normal controls.
Four other schizophrenic patients were replaced for making 20 or more press-errors, along with one normal for falling asleep, and one normal and one schizophrenic subject who received the wrong tone intensities.

All patients were interviewed by a clinical psychologist who had no knowledge of the psychophysiological data, using the Schedule for Affective Disorders and Schizophrenia (SADS) (Spitzer and Endicott 1977) and Research Diagnostic Criteria (RDC) (Spitzer and Endicott 1978) for definite chronic schizophrenia, or, for patient controls, for any definite psychiatric illness without schizophrenia. Normals were interviewed and accepted if they had never sought psychiatric help, gave no evidence of central nervous system pathology or significant head trauma, and had never abused drugs or alcohol. SADS interviews were randomly recorded and used for independent diagnosis by another psychologist. There were no disagreements.

Every subject filled out a handedness questionnaire (Gur 1977), with some schizophrenic patients being asked to act out each item. Only right-handed subjects were used.

All patients were obtained from the Kingsboro, Kings County, and South Beach Psychiatric Centers. Normal controls were primarily nonprofessional employees at these centers. All subjects were paid for participating.

Background characteristics for each sample are given in table 1. There were no reliable differences in age or male/female ratio. A difference in education \( F = 2.54; df = 5, 114; \ p < .05 \) was shown by Newman-Keuls tests to be due to greater education in the nonschizophrenic Press Group than in either schizophrenic sample. There is also a greater proportion of whites in both nonschizophrenic samples than in either the schizophrenic Press Group or the normal Nonpress Group \( (\chi^2 > 4.95) \).

The nonschizophrenic Press Group consisted of three minor and four major depressive disorders; three generalized anxiety disorders; two antisocial personality; three obsessive compulsive disorders; and five bipolar II disorders, currently hypomanic.

In the nonschizophrenic Nonpress Group, there were one minor and six major depressive disorders; two bipolar disorders, currently depressed (one each of types I and II); three generalized anxiety disorders; three antisocial personality; three bipolar II disorders, currently hypomanic; one labile personality; one unspecified psychosis.

Drug Status. Ten schizophrenics were drug-free a minimum of 2 weeks at testing (confirmed by Forrest test); five were assigned to the Press, and five to the Nonpress Group. Of the remaining 30 schizophrenic patients, six were receiving chlorpromazine (100–1000 mg/day); five, thioridazine (100–600 mg/day); nine, haloperidol (4–10 mg/day); one, trifluoperazine (5 mg/day); seven, fluphenazine decanoate (5–25 mg every 3 weeks); and two, thiothixene (20–40 mg/day).

Among nonschizophrenic subjects, 17 were nonmedicated, seven in the Nonpress and 10 in the Press Group. Of the remaining 23, three were receiving chlorpromazine (100–800 mg/day); three, trifluoperazine (4–6 mg/day); four, thioridazine (50–200 mg/day); one, fluphenazine hydrochloride (30 mg/day); eight, lithium carbonate (900–1800 mg/day); three, thiothixene (20–30 mg/day); and one, perphenazine (6 mg/day) plus amitriptyline (30 mg/day).

### Table 1. Background characteristics for each sample

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Drugs and dosages were similar for Press and Nonpress Groups.

Procedure. Subjects were seated in an air-conditioned, sound-deadened test chamber, told they would hear tones over earphones, assured they would not be unpleasant, and asked to sit still and remain awake. Transducers and earphones were attached and a 10-minute hydration period followed. To ensure against bias in lateral response symmetry, electrodes, amplifiers, and recording channels were alternated from one side to the other for successive subjects in each sample. Gauze pads were placed over each eye and held by a gauze strip wound lightly about the head. (Subjects were told the pads were to reduce eye movement which might disturb EEG records.)

Subjects in each diagnostic category were assigned in alternating fashion to Press Group (PG) or Nonpress Group (NPG) conditions. Half of each PG sample was instructed to press a foot pedal as quickly as possible to each high tone while ignoring the low. The other half had to respond in reverse fashion. Each correct press within 500 msec would win a 10c bonus, while wrong or slow presses would lose 10c. The right foot of each subject was used. (Subjects were told they would not be asked to say or do anything, and needed only to sit still.

Half the subjects in each group began with a high tone; half began with a low.

Stimuli were either 1000- or 2000-Hz, 1-second tones delivered binaurally at 60 dB (re .0002 dynes/cm²). They were repeated in alternating sequence with an intertrial interval randomized between 15 and 60 seconds until 60 of each pitch had been given. Tones and sequence were identical for PG and NPG samples. Every subject was monitored via closed circuit television in the adjoining instrument room.

As in our previous work (Bernstein, Taylor, and Weinstein 1975), on completing the trials, PG subjects were told they were finished but asked to press the pedal "a few times whenever you like so we can calibrate the instruments." As before (Bernstein, Taylor, and Weinstein 1975), pedal press per se had virtually no effect on SCR or FPV. More recently (Bernstein et al., submitted for publication), we examined the effect of pedal press on tonic and phasic electrodermal, eyeblink, and heart rate (HR) response. None was apparent on the first two, and only a circumscribed effect was seen on HR (briefly increased acceleration 1-2 seconds following the press signal). The conclusion reached was that the use of such brief pedal press to create stimulus significance would be unlikely to affect the data simply because of the motor effort per se.

Apparatus and Scoring. Recordings were made on a Beckman type R611 polygraph and Crown-Vetter Model A tape recorder.

Electrodermal response. These were obtained with Beckman 9844 skin conductance couplers (.5 volt constant voltage), using Beckman electrodes, paste, and collars, from the base of the first and third fingers of each hand after each site was scrubbed with acetone. An SCR was scored whenever a response of at least .05 μmho occurred within 1-3 seconds following any tone onset. SCL was read 1 second preceding each tone onset.

FPV response. These were recorded through Beckman #215659 photoelectric finger plethysmographs on the tip of each middle finger. Recordings were AC coupled with a 1-second time constant (TC).

Because of the recurrent constrictions encountered in FPV, response was defined as the occurrence of three consecutive pulses starting 1-7 seconds after tone onset which are all smaller than the three smallest consecutive pulses in the 6 seconds preceding the tone. FPV response was scored as percentage change in mean size (in mm) of these three poststimulus pulses from the mean of the three smallest consecutive prestimulus pulses.

EEG. Grass E55 electrodes and Beckman paste were attached by collodion to two occipital (01, 02) and two temporal (T3, T4) sites which had been scrubbed with acetone. Recordings were monopolar, referred to the linked earlobes. Signals were amplified and filtered (from 1.6 to 32 Hz at the 3 dB points) using a .3-second TC, and recorded on tape for off-line computer analysis.

Tape outputs were digitized at 128 samples per second. Each trial yielded 10 seconds of data, 5 seconds prestimulus, and 5 seconds poststimulus onset. Each trial thus yielded 1,280 data points, and was divided into 10 epochs of 1 second (128 samples) each. To eliminate baseline (DC) shift, the linear regression line for each 128 sample epoch was determined and removed from the raw data. To minimize spectral leakage, a 10 percent (i.e., first and last 12 points) raised cosine window-weighting function was applied to the remaining data and a fast Fourier transformation was performed.

On each trial, this analysis identified the power at each frequency from 4 to 29 Hz inclusive, during each of 5 prestimulus and 5 poststimulus seconds. Power at each frequency was averaged over the S-
second prestimulus period, and this was averaged by bandwidth: theta (4-7 Hz); alpha (8-13 Hz); beta 1 (14-20 Hz); beta 2 (21-29 Hz), identifying mean power for each bandwidth over the 5 pretrial seconds. These provided indices of EEG background activity, and were examined before trial 1 and averaged within successive five-trial blocks.

The ratio of power for each frequency in each poststimulus second was obtained relative to the mean power in that frequency over the 5-second prestimulus period, and this was expressed as a percentage. These poststimulus/prestimulus power ratios were averaged by bandwidth, and printed out as percentages for each bandwidth averaged over the 5-second poststimulus interval for each trial. These ratios measured phasic EEG response to the tones.

Alpha blocking criterion. To assess the frequency of OR in the EEG, some criterion of EEG-OR must be defined. The most commonly used index of EEG-OR is alpha blocking. Since there is no general agreement on a score to define such blocking, we earlier (Bernstein et al. 1981) examined several possibilities and adopted a criterion of a poststimulus/prestimulus reduction in alpha power of at least 20 percent. We therefore defined a suppression of at least 20 percent in poststimulus power within the 8-13 Hz bandwidth as our index of alpha blocking.

Respiration. This was monitored through a strain gauge around the chest, and allowed us to discard trials accompanied by respiratory irregularity.

Eyeblink. These were recorded via Beckman electrodes aligned above and below the right eye and allowed us to discard EEG trials accompanied by eye movement.

Tones were produced through EICO signal generators, delivered to Grason-Stadler TDH 39 earphones using an Iconix electronic switch to produce 25-msec rise/decay times.

A logic system controlled off-line computer processing by imposing a 1 volt 300 msec signal on a tape channel 5 seconds before the system triggered the tone. This started EEG computer processing for 10 seconds, divided into equal 5-second prestimulus and poststimulus periods. If the operators monitoring output detected movement, respiratory irregularity, or spontaneous activity in the prestimulus period, they imposed a second 100-msec voltage on that channel through a button push, aborting the trial until the record was more stable.

Results

Repeated measures effects in the analyses of variance (ANOVAs) to follow present unadjusted degrees of freedom, Greenhouse-Geisser (1959) epsilon corrections, and p values corrected for heterogeneity in the variance-covariance matrix. In addition, since SCR and FPV comparisons among diagnostic groups were similar for each hand, figures contrasting these samples present only right-hand data. Since the PG subjects received 60 Press tones (Pt) and 60 Nonpress tones (NPt) while NPG subjects received 120 NPts, comparisons between the NPt trials in PG and NPG samples were restricted to the first 60 trials in the latter. This was possible because there were no differences between responses to 1000- and 2000-Hz tones in NPG samples.

Response Frequency

SCR. Figure 1 presents the frequency of response in SCR on trial 1, which was relatively unaffected by habituation, as well as over successive trial blocks.

On the first trial, NPG schizophrenic subjects showed a greater frequency of nonresponsiveness (60 percent) than either normals or nonschizophrenic patients (25 percent each) ($\chi^2 = 5.01$, df = 1, $p < .05$). The incidence of nonresponsiveness to the first NPt tone in the PG sample did not differ significantly from that in the NPG samples. Schizophrenic subjects thus still displayed somewhat more frequent nonresponsiveness here than normals ($\chi^2 = 3.13$, df = 1, $p < .10$). Only with the Pt tone did schizophrenic subjects show a substantial decrease in nonresponsiveness vis-à-vis that in the NPG sample ($\chi^2 = 8.64$, df = 1, $p < .01$). When the initial Pt trial occurred, schizophrenic subjects displayed the same incidence of nonresponsiveness as the control samples (figure 1). Normal and nonschizophrenic subjects showed similar, rather low frequencies of nonresponsiveness under each condition.

To examine SCR frequency across trials, we compared groups by Kruskal-Wallis ANOVA on 10-trial blocks (TBs) #1, #3, and #6 (i.e., on the first, middle, and last block). Where these were significant, we followed with Mann-Whitney U tests.

For NPG samples, the ANOVA was significant on TB1 ($H = 8.59$, df = 2, $p < .02$), with U tests showing less frequent responding here by schizophrenic subjects than by either control ($U \leq 121.5$, $p < .05$). No differences appeared on TB3 or TB6.

The same results appeared for the NPt trials. Schizophrenic patients were less often responsive than either control on TB1 ($H = 8.84$, df = 1, $p < .02$; $U \leq 124.5$, $p < .05$) but not on either TB3 or TB6.

However, the reverse was true for
Pt tones. Here, TB1 yielded nonsignificant differences among diagnostic groups. Differences only appeared later, on TB3 ($H = 9.54, df = 2, p < .01$) and TB6 ($H = 7.85, df = 2, p < .05$). In each case, schizophrenic subjects were more frequently nonresponsive than either control ($U \leq 119.0, p < .05$), while the controls did not differ.

Wilcoxon tests within each sample showed that SCRs occurred more frequently to Pt than to NPt signals on TB1, TB3, and TB6 within each control sample ($all p < .01$), while schizophrenic subjects showed greater response frequency to Pt tones only on TB1 ($p < .01$).

Mann-Whitney tests compared response incidence in NPt and NPG trials. Normal subjects showed greater SCR frequency on NPt trials on TB1 ($U = 129.5, p < .10$) and TB3 ($U = 115.0, p < .05$), but no difference on TB6. Schizophrenic and nonschizophrenic subjects revealed greater response incidence to NPt tones on TB1 ($U = 124.5, p < .05$), but no difference on TB3 or TB6.

Table 2 lists median trials to habituation for each sample, with habituation defined as the first appearance of three consecutive nonresponsive trials. Logically, habituation could only be measured in subjects who were initially responsive. Mann-Whitney tests showed that responder schizophrenic subjects habituated faster than controls in all conditions: Pt, NPt, and NPG ($U > 27.0, p < .05$).

Comparing habituation scores for Pt and NPt trials within the PG samples, Wilcoxon tests showed slower habituation in every diagnostic group to the Pt signals ($each p < .01$). However, habituation to the NPt tones did not differ from

Figure 1. Frequency of SCR response in each diagnostic group on trial 1 and successive 10-trial blocks

For comparability, in this and all other figures, only the first 60 trials are presented for the NPG samples.
that shown by NPG samples.

**FPV response.** Figure 2 displays the frequency of FPV responses. On trial 1, NPG schizophrenic subjects showed more frequent nonresponsiveness than normals (20 percent: $\chi^2 = 6.67$, $df = 1$, $p < .01$) and a trend in this direction compared with nonschizophrenic patients (30 percent: $\chi^2 = 3.64$, $df = 1$, $p < .10$). There were no significant differences in response frequency between initial NPt and NPG trials, and schizophrenic subjects tended still to be more often nonresponsive to NPt tones than normals ($\chi^2 = 2.77$, $df = 1$, $p < .10$). As with SCR, schizophrenic subjects displayed a drop in FPV nonresponsiveness to the initial Pt trial compared to the initial NPG trial ($\chi^2 = 8.64$, $df = 1$, $p < .01$), and showed the same frequency of FPV OR initially to Pt tones as did controls.

In the NPG samples, Kruskal-Wallis ANOVAs revealed significant differences in FPV OR frequency on TB1, TB3, and TB6 ($H \geq 10.63$, $df = 2$, $p < .01$). On TB1 and TB3, $U$ tests showed greater nonresponsiveness in NPG schizophrenic subjects than in their controls ($U \leq 113.5$, $p < .02$). On TB6, normals still displayed more frequent responses than schizophrenic subjects ($U = 106.5$, $p < .02$). (As figure 2 shows, this more protracted superi-

Table 2. Median trials to habituation criterion

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Note.—Schiz = schizophrenic patients; Nonschiz = nonschizophrenic psychiatric patients; Norm = normal controls.

ority in FPV than in SCR OR frequency among NPG controls occurred because they reached FPV asymptotes at 10-20 percent response frequency rather than declining to zero levels as in SCR.)

On NPt trials, TB1 revealed a significant difference ($H = 7.70$, $df = 2$, $p < .05$) due to greater nonresponsiveness among schizophrenic than normal subjects ($U = 80.5$, $p < .002$). There were no differences among samples on TB3 or TB6.

As with SCR, the reverse was true for Pt tones. No differences were found on TB1, but these appeared on both TB3 and TB6 ($H = 7.96$, $p < .02$). On TB3, $U$ tests showed more frequent responses among normal than schizophrenic subjects ($U = 115.5$, $p < .05$), with a similar trend for nonschizophrenic vs. schizophrenic patients ($U = 134.5$, $p < .10$). On TB6, both control groups exhibited more frequent Pt ORs than schizophrenic subjects ($U \leq 124.5$, $p < .05$).

As with SCR, initially responsive schizophrenic subjects showed faster FPV habituation than controls in both NPG and Pt trials ($U \leq 23.5$, $p < .02$). They were also faster on NPt trials (table 2) but failed to reach significance here.

Wilcoxon tests again revealed more frequent FPV ORs on Pt than NPt trials in every sample, while Mann-Whitney comparisons showed no significant differences between NPt and NPG trials.

Wilcoxon tests revealed slower FPV habituation to Pt than to NPt tones in every sample, but gave nonsignificant differences between NPt and NPG habituation scores.

**Consistency of nonresponsiveness.** Ten of the 12 NPG schizophrenic subjects who were SCR nonresponders were also FPV nonresponders (83 percent). For the combined NPG samples, only 3 of 10 SCR nonresponders (30 percent) were also FPV nonresponders. Significantly greater SCR-FPV consistency was thus shown by the schizophrenic subjects ($\chi^2 = 4.40$, $df = 1$, $p < .05$).

**EEG.** Figure 3 illustrates the frequency with which subjects reached the 20 percent alpha blocking criterion.

The incidence of responsiveness on trial 1 was compared among diagnostic samples at each EEG lead for NPG, NPt, and Pt tones. Reliable differences emerged only in the NPG comparisons, where schizophrenic subjects were less often responsive than normal subjects in the left temporal lead ($\chi^2 = 3.84$, $df = 1$, $p = .05$). However, any conclusions concerning specific left temporal deficit must be treated cautiously, since schizophrenic subjects displayed an even lower response incidence in
the left occipital lead (figure 3). The left temporal difference seems to owe more to an unusually high incidence of response among normals here, above that of nonpsychotic patients as well (χ² = 5.10, df = 1, p < .05). Figure 3 suggests, instead, some trend toward greater difference between schizophrenic and normal subjects in left hemisphere criterion alpha response generally in the NPG condition. No differences are suggested for either hemisphere during the NPt or Pt tones for the PG sample.

Because EEG response once again (see Bernstein et al. 1981) showed greater intertrial variability than the autonomic measures, alpha response over trials was available only as mean change over five-trial sequences. Such data do not lend themselves to a definition of trials to habituation. Instead, we compared diagnostic groups in frequency of meeting the alpha blocking criterion at each EEG lead for each such average. None of the differences were significant.

We examined the consistency of nonresponsiveness between each autonomic response and EEG response defined by criterion alpha blocking. Among schizophrenic subjects, 46 percent of SCR nonresponders (48 percent for FPV nonresponders) were also alpha blocking nonresponders. Among combined controls, the figures were 30 percent (31 percent). While schizophrenics were again more consistently nonresponsive, the difference is not significant.

Response Amplitude

SCR. Figure 4 displays mean SCR amplitudes for each sample. Within the PG samples an ANOVA on trial 1 examined the effects of diagnosis, Pt/NPt tones, and hands; a repeated measures test examined the same
factors over trial blocks. Another ANOVA examined trial 1 across PG and NPG samples for the effects of diagnosis, NPt/NPG trials, and hands; while a fourth (repeated measures) test added the factor of trial blocks.

Within the PG sample, the differences in trial 1 SCR amplitude among diagnostic groups suggested by figure 1 proved nonsignificant ($\mu = .202$). The Pt/NPt main effect, however, was significant ($F = 24.15; df = 1, 54; p < .001$), with larger initial SCRs elicited by Pt tones. The absence of any diagnosis interaction indicates that this increase in SCR to the first Pt tone was similar in all diagnostic groups.

Across trials, the PG sample revealed a TB effect ($F = 12.10; df = 11, 594; \epsilon = .424, p < .001$) pointing to SCR habituation in all samples. In addition, the larger SCRs seen in all groups to Pt tones on trial 1 were continued across trials (Pt/NPt effect, $F = 48.41; df = 1, 54; p < .001$). There were also significant diagnosis ($F = 4.56; df = 1, 54; p < .02$) and diagnosis by Pt/NPt effects ($F = 4.41; df = 2, 54; p < .02$) over trials. Newman-Keuls tests showed that PG schizophrenic subjects displayed smaller overall response to the Pt tones, consistent with the habituation scores.

A TB main effect also appeared ($F = 18.88; df = 11, 1254; \epsilon = .437; p < .001$), indicating SCR habituation. In addition, the NPt/NPG factor was significant ($F = 17.97; df = 1, 114; p < .001$).

Figure 3. Frequency with which subjects in each diagnostic group met the 20% alpha blocking criterion in each EEG lead on trial 1 and successive 10-trial blocks

NONPRESS GROUPS

PRESS GROUPS, PRESS TRIALS
revealing larger SCRs over collapsed NPt than NPG trials.

FPV response. Figure 5 displays mean FPV response amplitudes. The ANOVA examining initial FPV response in PG subjects found the Pt/NPt factor significant ($F = 22.13; df = 1, 54; p < .001$), with greater constriction elicited by Pt tones. The absence of a diagnosis interaction indicates that the Pt/NPt difference on the initial trial was similar across diagnostic groups. A main effect for diagnosis did appear, however ($F = 5.75; df = 2, 54; p < .01$). Newman-Keuls tests showed that schizophrenic subjects gave initial FPV responses similar to those of nonschizophrenic patients, and that both were smaller than in normals. Over PG trials, a TB effect ($F = 14.53; df = 11, 594; \epsilon = .871; p < .001$) reflected FPV habituation.

Comparison of the initial NPt and NPG trials yielded only a diagnosis effect ($F = 8.96; df = 2, 114; p < .001$). Newman-Keuls tests again showed similar response amplitude in schizophrenic and nonschizophrenic patients, smaller in each than in normals. The same diagnosis effect appeared over trials ($F = 11.57; df = 2, 114; p < .001$), while a TB effect ($F = 13.42; df = 11, 1254; \epsilon = .616; p < .001$) reflected habituation in all samples.

As figure 5 reveals, overall mean FPV response across trials was not very different for NPt and NPG trials (5.4 vs. 3.8 percent, respectively). Nevertheless, an ANOVA showed this to be a reliable difference ($F = 4.47; df = 1, 114; p < .04$). Thus, although NPt-NPG differences are smaller in FPV than in SCR, both show the same pattern—almost identical mean amplitudes to initial NPt and NPG trials, with larger responses sustained thereafter during NPt repetitions.

EEG response. Figure 6 displays phasic EEG responses for each bandwidth (BW). These data were not separated for diagnostic samples because there were no substantive differences among them. Of the four ANOVAs examining EEG response in PT vs. NPt, and in NPt vs. NPG conditions, diagnosis was significant only in two uninterpretable third order interactions in the Pt-NPt analysis over trials. Thus, the reduced EEG response obtained among schizophrenic patients when frequency of criterion alpha blocking was considered was not apparent when all bandwidths were examined and no minimal response criterion was imposed.

The analysis of trial 1 response in the PG sample revealed a main effect for bandwidth ($F = 26.61; df = 3, 168; \epsilon = .871; p < .001$). Newman-Keuls tests showed that alpha blocking was greater than all other responses, and that theta suppression was greater than beta-2 response. The analysis also yielded a borderline Pt/NPt effect ($F = 3.84; df = 1, 56; p = .055$) with poststimulus vs. prestimulus power ratios of 91.7 percent in the first Pt trial and 86.3 percent in the first NPt. This appears to suggest greater response to the initial NPt tone, contradicting the autonomic data.
However, the issue is clarified by the ANOVA over trial blocks in the PG samples, which yielded a bandwidth main effect ($F = 51.53; df = 3, 159; \varepsilon = .802, p < .001$) and, more importantly, a Pt/NPt $\times$ BW interaction ($F = 18.49; df = 3, 159; \varepsilon = .806; p < .001$). As figure 6 indicates, Pt tones produced a different pattern of EEG response than NPt tones, combining greater decrease in alpha and theta power with greater increase in beta-1 and beta-2. Thus, Pt signals did produce greater EEG response than the NPt tones, displayed as a greater shift from slower, high voltage, to faster, low voltage output. Further, the NPt vs. NPG ANOVA did not reveal an analogous NPt/NPG $\times$ BW interaction. Thus, EEG activation, the shift from slower to faster activity, appeared solely to PT tones.

Unlike the autonomic responses, however, the EEG Pt-tone response is similar in schizophrenic and control subjects, both initially and over trials. ANOVAs comparing response to NPt vs. NPG tones also failed to show any differences involving diagnosis. Thus, every analysis of phasic EEG response other than that based on frequency of criterion alpha blocking points to a similarity between schizophrenic and other subjects.

Figure 4. Mean SCR amplitude for each diagnostic sample on trial 1 and over successive 5-trial blocks
While details are omitted to save space, both the PG and NPt vs. NPG ANOVAs pointed to a particular habituation of alpha blocking over trials—e.g., comparison of TB1 vs. TB12 in overall PG response showed a decrease of 12.9 percent in alpha response against 0.8 to 4.8 percent in other bandwidths.

Lateralization Effects in Phasic Response. Table 3 lists SCR and FPV response amplitudes for each hand. There were no significant differences in FPV response between hands, but these did appear in SCR. Analysis of first trial SCRs between Pt and NPt tones yielded significant hands effects ($F = 6.33; df = 1, 54; p < .02$) and hands $\times$ Pt/NPt effects ($F = 4.50; df = 1, 54; p < .04$). These were due to generally larger right-hand SCRs, and to still further increment in the right-hand superiority when the Pt tone was heard. Trial 1 analysis of NPt/NPG response also showed an effect of hands ($F = 3.98; df = 1, 114; p < .05$).

Over trials, the Pt/NPt ANOVA displayed the same hands ($F = 6.75; df = 1, 54; p < .02$) and hands $\times$ Pt/NPt effects ($F = 5.59; df = 1, 54; p < .03$) as on trial 1. The NPt/NPG analysis over trials revealed another main effect of hands ($F = 5.32; df = 1, 114; p < .03$) but also showed a hands $\times$ NPt/NPG interaction ($F = 4.24; df = 1, 114; p < .05$).

**Figure 5.** Mean FPV response amplitude for each diagnostic sample on trial 1 and over successive 5-trial blocks.
Thus, targeted signals were associated with larger SCRs generally, but elicited particularly larger responses from the right hand. While this special enlargement of right-hand SCR was restricted to the target signal on the initial trial, over repeated trials some further right-hand enlargement was also seen to NPt tones relative to NPG. Nevertheless, the relative increase in right-hand SCR was greater to Pt than to NPt tones.

Evidence of asymmetrical EEG response was also found. Analysis of

Figure 6. Mean phasic (poststimulus/prestimulus power ratio) EEG response in each bandwidth averaged across diagnostic samples on trial 1 and successive 5-trial blocks

Table 3. Response amplitudes in each hand for SCR (µmhos) and FPV (% constriction)

<table>
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<th>Nonpress groups</th>
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<td>FPV</td>
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<td>RH minus LH</td>
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Note.—LH = left hand; RH = right hand.
trial 1 NPt vs. NPG responses revealed bandwidth ($F = 22.47; \text{df} = 3, 339; \epsilon = .923; p < .001$), BW $\times$ NPt/NPG ($F = 3.51; \text{df} = 3, 339; \epsilon = .923; p < .02$), and BW $\times$ NPt/NPG $\times$ hemisphere effects ($F = 2.99; \text{df} = 3, 339; \epsilon = .986; p < .04$). Scheffe tests revealed that (1) differences in response to the initial NPt and NPG tones were largely due to greater alpha blocking to NPt and (2) that this difference in alpha blocking was greater in the left hemisphere. The superiority of left hemisphere response diminished somewhat over trials so that the BW $\times$ NPt/NPG $\times$ hemisphere interaction appeared only as a trend across trials ($F = 2.25; \text{df} = 3, 339; \epsilon = .859; p = .09$).

In the Pt vs. NPt ANOVAs, however, no differences in lateralization of EEG appeared.

There were no differences between schizophrenic and control subjects in SCR or FPV lateralization. In the most general analysis of EEG, that across all bandwidths, schizophrenic patients again displayed the same bilateral pattern as control subjects. Only in the incidence of criterion alpha blocking was there (weak) evidence of EEG asymmetry consisting of reduced left hemisphere response, but this appeared in nonschizophrenic as well as schizophrenic patients.

Background (Tonic) Levels

SCL. Figure 7 displays SCL, square-root-transformed to reduce skew, preceding the first trial and every 10th trial thereafter for the 60 Pt and NPt trials. Comparable values are presented for the first 60 NPG tones.

When schizophrenic and nonschizophrenic patients were compared on Pt vs. NPt trials, a Pt/NPt effect ($F = 6.22; \text{df} = 1, 36; p < .02$) revealed higher SCL for the Pt trials, though the difference is very small (3.48 vs. 3.44 V/μmho). In addition, a Pt/NPt $\times$ trials interaction ($F = 6.21; \text{df} = 6, 216; \epsilon = .745; p < .001$) indicates that increment in SCL occurred over trials, and was greater for Pt tones; for example, the difference between first and last SCL was .328 V/μmho for Pt trials and .220 for NPt.

EEG background power. An ANOVA examined background EEG in each bandwidth, lead, and hemisphere in the 5 seconds preceding initial Pt and NPt tones. A significant effect appeared for bandwidth ($F = 41.84; \text{df} = 3, 159; \epsilon = .392; p < .001$). Newman-Keuls tests showed greater power in alpha than in any other band, and greater

**Figure 7. Mean SCL values for each diagnostic (and drug) group preceding trial 1 and every 10th trial thereafter for the 60 Pt and NPt trials, and for the first 60 NPG trials**
Figure 7. Mean SCL values for each diagnostic (and drug) group preceding trial 1 and every 10th trial thereafter for the 60 Pt and NPt trials, and for the first 60 NPG trials—Continued

power in theta than in either beta band. Both lead \( (F = 22.11; \text{df} = 1, 53; p < .001) \) and lead \( \times \) BW effects \( (F = 24.24; \text{df} = 3, 159; \epsilon = .362; p < .001) \) were due to heightened alpha at the occiput; i.e., occipital power was roughly double that of the temporal lead for theta and beta bands, but over six-fold greater for alpha.

Similar bandwidth, lead, and BW \( \times \) lead effects were seen in the first trial NPt-NPG analysis, and across trials in both Pt-NPt and NPt-NPG analyses.

In addition, each ANOVA over trial blocks revealed a TB \( \times \) BW interaction: for Pt vs. NPt \( (F = 2.54; \text{df} = 33, 1749; \epsilon = .150; p < .05) \); for NPt vs. NPG \( (F = 2.00; \text{df} = 33, 3729; \epsilon = .283; p < .04) \). Each reflected a greater increase over trials in theta and alpha power than in beta; for example, comparing mean power in TB11 and TB12 with that of TB1 and TB2 showed a rise of 2.12 and 1.99 \((\mu V/\text{cycle})^2\) in theta and alpha versus .19 and .05 values for beta 1 and 2 in the Pt-NPt analysis.

Lateralization Effects on Tonic Levels. Analysis of SCL scores for each hand revealed no significant differences in any sample. Electrodermal asymmetry was thus restricted to phasic SCRs only. In contrast, examination of EEG background power revealed diagnosis \( \times \) hemisphere \( \times \) lead \((F = 4.57; \text{df} = 2, 53; p < .02) \) and diagnosis \( \times \) hemisphere \( \times \) bandwidth effects \((F = 3.38; \text{df} = 6, 159; \epsilon = .473; p < .03) \). Newman-Keuls tests showed these interactions reflected reduced left occipital background alpha power among schizophrenic subjects relative to either control group.

Drug Effects. The drug effect on SCL suggested in figure 7 was supported by ANOVA. When schizophrenic and nonschizophrenic NPG samples were compared, the drug effect \( (F = 13.95; \text{df} = 1, 36; p < .001) \) reflected lower SCL in drug samples. The effect was similar in each patient population since no diagnosis effects were seen.

In contrast, when unmedicated patient samples were compared with normals on NPG trials, a diagnosis effect did appear \( (F = 5.38; \text{df} = 2, 29; p = .01) \), reflecting higher SCL in each drug-free patient group. When the drug-free patients were compared with normals over PG trials, Pt/NPt \( \times \) trials \((F = 3.39; \text{df} = 6, 192; \epsilon = .610; p < .02) \) and Pt/NPt \( \times \) trials \( \times \) diagnosis effects \((F = 2.05; \text{df} = 12, 192; \epsilon = .610; p < .05) \) were found. These reflect the fact that while each group showed greater SCL increment over Pt trials, the increase was greater for schizophrenic subjects than for any other sample, and greater for normals than for nonmedicated nonschizophrenic patients (by Scheffé test).

Thus, when patients were not receiving neuroleptics, their SCLs were different from those of normal subjects—significantly higher in the NPG condition, and different also in rate of increment in the PG sample.

Examination of SCL in all patients for NPG and NPt trials suggested a drug \( \times \) NPt/NGP interactive trend \((F = 2.94; \text{df} = 1, 72; p = .09) \) seen in figure 7. While the effect of the PG instructions was to raise SCL in the medicated patient samples just as it did in normals, the effect on the nonmedicated patients was to lower SCL, bringing it within normal limits without drugs.

To determine whether other drug effects existed, further ANOVAs compared drug-treated and drug-free subgroups in SCR and FPV response, and in both EEG background levels and phasic response. No significant results emerged.
Behavioral Responses. Figure 8 displays mean reaction times (RTs) and frequencies of omission (missed) and commission (wrong) errors on each trial block. For RT, ANOVA gave a diagnosis effect ($F = 9.13; df = 2, 57; p < .001$), which Newman-Keuls tests showed to reflect slower reactions in schizophrenic subjects. No other differences were significant.

There were too many zeroes in the error data for useful statistical analysis. Figure 8 suggests, however, that schizophrenic patients were not different in error rate. (It should be noted, however, that those making more than 20 errors were not accepted as subjects.)

Nonresponsiveness Among Depressed Patients. Because of recent suggestions of heightened nonresponsiveness in depression, we reexamined the nonschizophrenic samples. Nine patients in the nonschizophrenic NPG sample and seven in the PG sample were diagnosed as currently depressed.

While the small $n$'s and post hoc comparisons make detailed testing inappropriate, the general trends in these data suggest something interesting.

The incidence of SCR nonresponsiveness among depressives on the first NPG, NPt, and Pt trials, respectively, is 33, 43, and 43 percent. For nondepressed nonschizophrenic patients, equivalent figures are 18, 8, and 0 percent. The incidence of initial FPV nonresponsiveness in depressives, in the same order, is 22, 57, and 29 percent, and for nondepressed nonschizophrenic patients 36, 45, and 15 percent. For EEG response, the average frequency across leads with which depressed patients failed to meet the 20 percent alpha blocking criterion was 61 percent on the initial NPG trial, 12 percent on NPt, and 46 percent on the Pt trial. For nondepressed patients, the figures were 36, 35, and 37 percent.

While not conclusive in themselves, these figures are concordant with the suggestion of diminished initial responsiveness among depressives in SCR, and perhaps in criterion alpha blocking. Beyond this, they suggest also that the targeting of significant tones did not increase responsiveness among depressives as it clearly did for schizophrenic subjects.
Table 4 displays mean autonomic responses for depressed patients and others on the initial tone in each condition. Even without statistical testing, a different trend is suggested for depressives than for schizophrenic patients, nondepressed patients, and normals. For each of the latter groups, both SCR and FPV display similar response amplitudes to NPt and NPG tones, with a considerable increase seen to the initial Pt signal. Depressives, however, show flat or even diminishing responses here, more clearly in the between-subjects (NPG vs. Pt) than in the within-subjects (NPt vs. Pt) comparisons.

**Discussion**

First, this study confirms our earlier work on the incidence and the breadth of OR nonresponsiveness in schizophrenia, and on the possibility of reducing this incidence. Given tones of moderate intensity and without explicit reason to attend to them, approximately half the schizophrenic subjects were again found to be nonresponsive, in both SCR and FPV OR components. In fact, schizophrenic subjects who were nonresponsive in SCR were more likely than either nonschizophrenic patients or normals to be nonresponsive in FPV as well. This consistency across independent components makes it apparent that the schizophrenic deficit is in the OR rather than in some peripheral response system.

The findings concerning phasic EEG response were somewhat more ambiguous. Applying the 20 percent criterion for alpha blocking, we found schizophrenic patients to be more frequently nonresponsive than normals in one lead. Such a result appears consistent with the autonomic data, and with other published results; for example, Dmitriev et al. (1968) also reported impaired responsiveness in both EEG and autonomic measures among schizophrenic subjects.

However, examination of EEG response over all four bandwidths without the imposition of an arbitrary criterion level found no differences between schizophrenic and control subjects. Others have also reported unimpaired EEG reactivity in schizophrenics (e.g., Fedio et al. 1961; Hein, Green, and Wilson 1962). Our own previous work with this alpha-blocking criterion also found no differences for the schizophrenic patients. We noted that the reduced response seen this time might be due simply to an unusual incidence of normal response here; we cannot yet be sure whether the current finding is real or artifactual. In either case, it points to the complex nature of the relationship between EEG and autonomically mediated reactivity. It should be noted too that Marsh and Thompson (1977) reported an ANS-EEG dissociation among the aged similar to what we think is the major thrust of our data with schizophrenic patients; i.e., autonomic responses were diminished, but EEG responses were not. Interestingly, they also reported that "highly meaningful material" improved autonomic response in the aged, again consistent with our data for schizophrenia.

When these stimuli were made explicitly significant for the subject

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by requiring him to respond behaviorally to specific tones, nonresponsiveness among schizophrenic patients fell to the same level seen among controls in SCR, in FPV, and in criterion alpha blocking. This finding sustains our earlier work and that of Gruzelier and Venables (1973) showing that engagement of the OR can be incited with normal frequency among schizophrenic subjects provided one does not leave it to the patient's idiosyncratic evaluative process to decide whether the field contains a significant signal, or just which of the available stimuli carries significant information.

The data also show that this increased responsiveness in schizophrenic subjects is not the result of indiscriminate reactivity associated with a heightening of general arousal. The schizophrenic subjects showed an initial heightening of OR primarily to the targeted signals, resembling the control groups in this respect. A similar heightening of response was not seen to the nonsignificant (NPT) tones presented alternately. Here, schizophrenic subjects continued to show initially reduced response incidence compared to normals at the same time ORs to targeted tones reached normal levels.

To use an old analogy, the OR-associated central processor may be likened to a high intensity, narrow focus beam (Wachtel 1967) capable of illuminating with great clarity any object on which it is turned, but of doing so for only one object at any time. To function effectively, such a system must have at least two major qualities: (1) Once allocated to a given object, it must continue to operate on it as long as the user wishes to continue drawing information from it. (2) When the focus of interest shifts, it must be flexible enough so the user can uncouple it from the previous object and recouple (reallocate) it to the next. A study of OR flexibility, looking both at uncoupling and recoupling capacity in schizophrenia, is now underway in our laboratory. One purpose of the present study was to examine the capacity of schizophrenic subjects to sustain OR activity as focal stimuli presenting significant information continue in a prolonged series.

It may seem paradoxical to emphasize sustained OR activity since many consider rapid habituation to be a definitional requirement of the OR. However, the emergence of an informational conception of the OR (Bernstein 1979, 1981a; Bernstein and Taylor 1979; Ohman 1979) emphasizes that such habituation will occur only to the extent that stimulus information declines. Thus, Bernstein and Taylor (1979) demonstrated no decline in SCR amplitude over trials, despite stimulus familiarization, so long as the information value of the (significant) stimuli did not diminish (see also Graham, Putnam, and Leavitt 1975).

This study reveals further deficiency in the OR, once initially allocated, among schizophrenic subjects in their relative inability to sustain the response over repeated calls. The normalization produced by explicit stimulus targeting was thus seen to be restricted to the initial presentation, and perhaps the 10 or 20 repetitions following. Beyond that, schizophrenic subjects displayed a sharp fall-off in both OR frequency and amplitude, significantly greater than that of normals or non schizophrenic patients, as target signals continued. This was evident in both SCR and FPV, pointing again to a decline in OR rather than in peripheral response per se. Because of the greater intertrial variability of EEG response and our consequent reliance only on five-trial averages, it is difficult to define EEG response here with equal precision. Insofar as these 5-trial scores were concerned, however, there was no evidence of a similar decline among schizophrenic subjects. EEG and autonomic responses therefore seem to diverge here again.

In one other sense, however, the abnormal decline in autonomic OR among schizophrenics may help bring them more in line with the results obtained with another EEG-derived measure, the P300 wave of the evoked potential (EP). Several authors have described the P300 as an OR component (e.g., Ritter, Vaughn, and Costa 1968; Roth 1973; Friedman 1978). If so, one might expect schizophrenic subjects to show diminished responsiveness here too.

In fact, studies have consistently reported reduced P300 in schizophrenia (e.g., Roth and Cannon 1972; Roth et al. 1980; Shagass 1976). While this suggests agreement between autonomic and EP activity, Bernstein (1981b) noted that P300 studies report a deficit among schizophrenic subjects in precisely those situations where several studies of autonomic OR report normalization—i.e., those dealing with explicitly significant signals.

Donchin (1981) has suggested P300 and autonomic responses might reflect somewhat different aspects of the attentional process. While this remains an important possibility, the present data suggest that variance from another source must be considered as well. Typically, SCR and FPV are scored on individual trials, or averaged over no more than two to five trial blocks. In contrast, EPs have typically been averaged over 30 to 40 or more repetitions. If the present study is correct in reporting that targeted signals initially elicit normal-like ORs in
schizophrenic subjects but decline quickly thereafter, we would expect previous autonomic studies, based on 10–20 trials as a rule, to have reported control-like ORs to significant stimuli, while the P300 was found to be deficient. Had we averaged SCR and FPV over 30 or more trials here, we would also have reported an OR deficit. Averaging over lengthy trial blocks may have led the P300 to reflect the greater decline in response among schizophrenic subjects without allowing it to record the stronger early response to such signals. Supporting such a possibility, Courchesne, Hillyard, and Galambos (1975) have reported rapid P300 habituation over the first few trials; for example, a decline of 50 percent in amplitude between trials 1 and 2, and a further 10 percent between 2 and 3 (see also Kok and Looren de Jong 1980). It would be of interest to examine P300 among schizophrenic patients to the first several target tones on a trial-by-trial basis.

We do not know the origin of this abnormally rapid OR decline to target stimuli among schizophrenic patients. Either of two explanations can be argued. For one, it may represent faster habituation. Using trial-to-habituation score, we noted faster habituation among schizophrenic subjects in all tone conditions, and have reported similar findings before (Bernstein 1970; Bernstein et al. 1981). Some laboratories have obtained similar results, though others dispute them (see cross-laboratory data in Bernstein et al. 1982). If habituation is the reason, it would suggest an active “ego-syntonic” process—a deliberate disengagement due either to a more efficient assimilative process having more quickly reduced stimulus uncertainty below critical levels (Sokolov 1966), or to differences in those critical levels such that schizophrenic patients accept less detailed, less finely assimilated models of the environment.

The other argument is that schizophrenic patients may be impaired in the ability to engage ORs repeatedly to a given target. The focus may be lost, its significance forgotten, the processor may switch prematurely, or the ability to sustain a given focus may be subject to growing inhibition. In this sense, schizophrenic patients would not be deliberately disengaging but rather be unable to continue. Such a problem might resemble Shakow’s (1963) hypothesized inability to sustain major set.

Further study is needed to select among these possibilities. For example, it would be useful to know whether schizophrenics could sustain ORs to target signals if they were retargeted periodically. In any case, this rapid decline in autonomic ORs is clearly not the result simply of smaller initial response since it occurs even when schizophrenic subjects make initial ORs similar in frequency and amplitude to those of other groups.

This study also attempted to determine whether there is a distinctive pattern of lateral asymmetry in autonomic and EEG reactivity in schizophrenia. In the autonomic responses, there was no specifically schizophrenic asymmetry. Instead, schizophrenic subjects simply displayed the same bilateral patterns seen in controls. Where the latter showed no differences between response in each hand (FPV), schizophrenic patients showed the same pattern. Where controls displayed a larger right-hand reaction (SCR), enlarged still further in response to target signals, schizophrenic patients showed the same pattern. Thus, a number of studies have now failed to replicate the initial report by Gruzelier (1973) of reduced left-hand SCR specific to schizophrenia—for example, Patterson and Venables (1978); Tarrier, Cooke, and Lader (1978a); Bernstein et al. (1981); Straube’s data and Patterson’s data in Bernstein et al. (1982); Iacono (1982); Bartfai et al. (1983); Schneider (1983); Levinson and Edelberg (in press); and now the present study. Perhaps the time has come to conclude that bilateral asymmetry of autonomic ORs does not differentiate schizophrenic patients from other persons.

EEG findings, however, are somewhat more ambiguous. The present data suggest (and we feel they should not be taken as more than suggesting) that schizophrenic subjects failed to reach criterion alpha blocking more often than normals in the left hemisphere but not in the right. The data point also to an asymmetry in background EEG, with schizophrenic patients displaying less alpha power in the left occipital lead than either control group.

Our findings are thus in keeping with others indicating some deficit of left brain hemisphere response in schizophrenia, though perhaps pointing more specifically to the alpha bandwidth (and to its presumably distinctive generator within the brain). The precise functional meaning of such a deficiency is not yet entirely clear. To make matters more complex, the literature is not consistent regarding EEG hemispheric asymmetry. While several authors have reported it (e.g., Flor-Henry 1976; Serafetinides 1972, 1973), some have not (e.g., Tarrier, Cooke, and Lader 1978b; Bernstein et al. 1981; Iacono 1982). Our own laboratory exemplifies the problem, having obtained a distinctively schizophrenic EEG asymmetry in this study but not in a previous one.
Clearly, we need further study to clarify the nature, focus, and meaning of this possible alteration in left-brain function among schizophrenic patients, and to determine why it does not seem to be reflected in autonomic response. These patterns of bilateral asymmetry also highlighted the fact that the relationship between EEG and ANS response or, for that matter, between ANS responses appears to be quite complex and still poorly understood. Thus, schizophrenic patients showed reduced alpha response and background power in the left hemisphere. Yet, this did not translate into differences in the nature of response asymmetry in SCR, SCL, or FPV. Further, all samples displayed greater alpha blocking in the left hemisphere than in the right (something we noted earlier as well; Bernstein et al. 1981). Perhaps the best current evidence with regard to lateralized cortical-electrodermal relationships indicates a likely contralateral inhibitory relationship (Lacroix and Comper 1979) (though an ipsilateral excitatory mechanism cannot entirely be ruled out). Since alpha blocking constitutes the primary element in the EEG response, such a relationship should have produced a larger left-hand SCR, at least in the NPt-NPG comparisons where the alpha lateralization was seen. In fact, just the reverse occurred.

Further discontinuities also exist in tonic response. While SCL increased over trials in the PG samples, indicating a heightening of activation, these samples simultaneously showed a greater net increase in power in the slower bandwidths, suggesting decreased arousal, and concordant with almost universal reports of increased drowsiness. It is possible that increased SCL in the PG sample may reflect continued effort to remain responsive despite increasing drowsiness (e.g., Malmo 1965). In any case, this reemphasizes the fact that important mediating decisions take place somewhere between the point at which EEG response is determined and that where autonomic response is determined.

In fact, important differences are apparent between one autonomic response and another. While SCR revealed (very small but consistent) lateralization in all samples (as it did before: Bernstein et al. 1981), FPV response never did so (again as seen before: Bernstein et al. 1981). Important decisions are also made governing the differential distribution of the SCR which are not mirrored in the FPV.

The analysis of RT showed that while schizophrenic patients were, as always, slower than controls, the curve of RT over trials among schizophrenic patients paralleled that of the controls. Inspection of the error curves in figure 8 also suggests that schizophrenic patients showed a distribution over trials similar to the controls. This is somewhat surprising since the greater decline shown by schizophrenic patients in SCR and FPV ORs to Pt signals might have predicted a greater increase in RT and errors among them.

One reason for this discrepancy may lie in the nature of the trials. Virtually every normal and nonschizophrenic subject reported becoming aware of the alternating nature of the high/low tones after a few trials, and thus feeling able to predict whether the next trial would be Pt or NPt. Temporal uncertainty remained, however, since no one could predict time of onset. Controls described themselves as concerned with both accuracy (which became easy) and with keeping speed within the 500-msec limit (which was not easy for the foot pedal used). Thus, the controls had to remain attentive for each Pt signal, not so much to identify pitch as to identify signal onset as early as possible.

Many schizophrenic patients were too disorganized to give reliable information about whether they had become aware of the pitch alternation. If we can assume they did (and the similarity of their error curves to those of controls might support this), then they too could predict Pt/NPt identity, but not time of onset. Schizophrenic patients gave the impression of being concerned more with response correctness than speed. Hence, once they became more confident about the identity of forthcoming trials, they may have had less reason for attentiveness and thus allowed autonomic ORs to decline more to the Pt signals.

Medication did not influence these results, since, in keeping with most other work (Bernstein et al. 1982), no drug effects were seen in phasic OR. Only in the tonic SCL was a drug effect seen (Venables 1975), with a similar lowering of SCL in both schizophrenic and nonschizophrenic patients receiving neuroleptics. These declined to the normal range from levels significantly above normal in drug-free patients. This study also demonstrated that the neuroleptics accomplished this not by imposing rigid inhibitory restraints locking SCL into some lower level, but rather by a more flexible restraint allowing medicated patients to heighten SCL to the same degree as normals when circumstances like the PG instructions make such increase advisable.

The present data also suggest something else not previously reported. Both schizophrenic and nonschizophrenic patients who were free of drugs showed a unique lowering of SCL relative to the drug-
free NPG patients, when given the PG instructions. Possibly, the need for efficient behavioral activity mobilized these patients to produce a kind of self-directed correction of SCL arousal. Such a possibility deserves further exploration.

We wish to make it clear that PG and NPG drug-treated and drug-free patients involve different subject samples. It is, therefore, possible that group differences in susceptibility to drugs or some other not readily apparent factor may have intervened. Accordingly, our statements of “lowered” SCL are necessarily somewhat speculative. These statements gain strength, however, from the fact that the independently selected sets of patients—schizophrenic and nonschizophrenic—both showed the same effects! It seems most unlikely that some bias operating in selecting drug-treated and drug-free PG and NPG schizophrenic samples would have been precisely duplicated among the nonschizophrenic patients.

We reexamined those patients with a current diagnosis of depression. With regard to the issue of OR nonresponsiveness, the results, while not sufficient themselves to establish any position, do seem consistent with reports of heightened nonresponsiveness in this group (Janes and Strock 1982; Iacono et al. 1983). In addition, these findings suggest something noteworthy concerning the normalization of initial OR that appears to warrant further study. Unlike schizophrenic subjects, depressed subjects seem to display little evidence of increased OR when specifically targeted signals are presented. This is suggested most strongly in the similar incidence of SCR nonresponding among depressives on NPG, NPt, and Pt trials, and in the smaller OR amplitude on the initial SCR and FPV Pt trial as compared with that shown by the NPG group. On a within-subject basis, depressives did show some increase in initial OR amplitude on Pt relative to NPt tones, though here too the difference is smaller than that shown by others. We cannot say whether this reflects some capacity for response increment. Since these are post hoc comparisons, we made no effort to equate depressed patients for type or severity in PG and NPG samples. Clearly, these data indicate that the effect of stimulus significance on OR in depressives, and its difference from that of patients with schizophrenia, warrant further study. At present, they can only suggest that the OR may still differentiate schizophrenic from depressive patients because of distinctive reactions to the normalizing effects of explicit significance, and thus that OR nonresponding may have a somewhat different origin in each group.

The usefulness of the significance hypothesis concerning the OR is once again demonstrated. It helps provide greater understanding of differential engagement and habituation of OR in normals, of nonresponsiveness and normalization in schizophrenic patients, and now, perhaps, of nonresponsiveness among depressives which (if further work supports these suggestions) would provide distinctive patterns of OR deficit differentiating between schizophrenic and depressive patients.

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