habituation and conditioning of electrodermal responses in high risk children

Leonard F. Salzman and Robert H. Klein

The study of children at risk for the development of schizophrenia has many advantages with respect to explorations into the etiology of schizophrenia. However, only a few high risk investigations (Anthony 1968, Bell et al. 1975, B. Mednick 1973, S. Mednick 1966, 1971, and 1977, and Mednick and Schulsinger 1965 and 1968) are prospective studies in which there is an opportunity to examine aspects of the psychophysiology of these children.

Mednick has reported results from his comparison of a large group of high risk children, the offspring of schizophrenic mothers, with a matched control sample (Mednick 1966, 1971, and in press, and Mednick and Schulsinger 1965). In addition, Mednick has contrasted the responses of a subgroup of this high risk sample who have already shown evidence of significant psychopathology with those of another subgroup of children at risk who have not as yet demonstrated any noteworthy pathological behavior. The results suggest that hypersensitive and labile autonomic functioning is characteristic of the whole group of high risk children, but is present in an even more extreme degree in those children who subsequently display signs of psychopathology. The high risk children manifested shorter skin conductance response (SCR) latency to stress stimuli during conditioning, and they responded with greater SCR amplitude to stress and to generalization stimuli compared with the controls. In addition, Mednick found that high risk children showed significantly more rapid electrodermal recovery following exposure to stressful stimuli. Subsequent to Mednick's report of this aspect of his results, Ax and Bamford (1970) reported that chronic schizophrenics demonstrated more rapid recovery from autonomic disruption than control subjects. Similar findings were obtained by Gruzelier and Venables (1972 and 1973), but Maricq and Edelberg (1975) reported opposite results.

Van Dyke (1972) explored orienting responses and classical electrodermal conditioning in a group of high and low risk adult subjects. His high risk subjects produced significantly larger electrodermal responses to orienting stimuli and a greater frequency of responses to the unconditioned stimulus (UCS) during conditioning. There were no differences between the two groups in response latency, basal level, recovery rate, conditioning, or habituation of responses. It is of special interest that no differences were found in the amplitude of responses to the UCS. Thus there was only weak and inconsistent confirmation of Mednick's findings of greater reactivity in Van Dyke's (1972) high risk group, although the results are not strictly comparable because of the age differences between these two samples.

Erlenmeyer-Kimling's (1975) study of the children of schizophrenic parents also included exploration of electrodermal responses, but in her preliminary report she indicated a failure to replicate Mednick's findings in relation to electrodermal conditioning.

Janes and Stern (1976) compared children from schizophrenic parents with matched groups of children from parents undergoing hospitalization for physical ailments and from "normal" families. They conducted studies of electrodermal orienting, habituation, and conditioning, and reported that although there were no differences between offspring of various patient groups, biphasic skin potential responders were rated as more emotionally disturbed than uniphasic responders. Their results, however, are also difficult to compare with Mednick's data.

*Reprint requests should be addressed to the senior author at the University of Rochester Medical Center, 300 Crittenden Boulevard, Rochester, NY 14642.
because of differences in experimental procedure and in the variables measured.

With the exception of studies by Mednick (1966, 1971, and in press), Mednick and Schulsinger (1965 and 1968), Itil et al. (1975), Schachter et al. (1975), and Van Dyke (1972), most reports have pointed to the absence of psychophysiological differences between offspring of schizophrenic and nonschizophrenic patients (Garmezy 1974, Garmezy and Streitman 1974, and Klorman, Strauss, and Kokes 1977). However, Mednick (in press) has emphasized that evidence of deviant autonomic functioning among his group of high risk children is related not only to risk status as defined by the mother's psychiatric history including the presence of hallucinations, but also to family intactness and to criminality among the fathers of children at risk.

Thus, studies comparing autonomic functioning of high and low risk children have yielded a series of perplexing and inconsistent results. Differences in the findings reported often reflect differences in the sample studied, the specific psychophysiological parameters examined, the experimental design employed, and the statistical analyses performed. While thus far only Mednick has obtained data indicating a cluster of significant autonomic differences among high risk offspring, only Erlenmeyer-Kimling (1975) can be considered a replicative study.

As a part of a larger research project studying children at risk for the development of schizophrenia and their families, the present study examined measures of skin conductance obtained from such children during rest and during experiments testing habituation and conditioning of the SCR. A decision was made to try to replicate as closely as possible, except where methodological improvements could be introduced, the experimental design and measurement strategies employed by Mednick. Accordingly we hypothesized, consistent with Mednick's results, that during the conditioning procedure high risk children would manifest higher levels of electrodermal responsiveness and reactivity, more rapid electrodermal recovery, and greater conditioning and generalization compared with control offspring.

Method

Subjects

The subjects were a subsample of a large group of families investigated in the University of Rochester Child and Family Study. Families participating in this project met the following criteria at the onset of the research: (a) at least one parent had been hospitalized for a functional psychiatric disorder, i.e., excluding alcoholism, drug abuse, and organic brain syndrome; (b) the index child was a male 4, 7, or 10 years old; (c) the family was living together; and (d) all families were in social class II — IV (Hollingshead and Redlich 1958). Families in this study participated in an extensive program of investigation of the children, the parents, and the family as a group.

The subjects included in the present report were 42 10-year-old male children, 12 of whom were designated high risk while 30 were considered low risk subjects. Risk status was established by two diagnostic teams on the basis of the index parent's (identified patient) diagnosis. Information utilized by one of the diagnostic teams included interviews of the index parent using a standardized sign and symptom inventory and psychiatric history form of demonstrated reliability (Strauss, Wynne, and Cole 1976) as well as less structured clinical interviews. In addition, all hospital records were reviewed and ratings of symptomatology and social function were made using the Case Record Rating Scale (Strauss and Harder 1976). The other team arrived at its diagnostic judgments on the basis of information available in the patients' hospital records and from the patients' responses to an extensive clinical interview conducted by the senior member of that team.

After reaching their initial diagnostic decisions, the two teams met to formulate a consensus diagnosis. Patients receiving a consensus diagnosis of schizophrenia were characterized by hallucinations and/or delusions, cognitive

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1Informed consent was obtained after the nature of the procedures had been explained fully to the children's parents.
disorganization, and absence of a primary affective component to their symptoms. The consensus schizophrenics and an additional small group of three patients who had been diagnosed schizophrenic according to DSM III (Spitzer, Endicott, and Robins 1975) criteria by one of the two teams were combined to provide a larger group of index parents considered as a broadly defined schizophrenic group. Other more operational ways of subtyping the parents are described elsewhere (Salzman, Klein, and Strauss, in press, and Strauss, Harder, and Chandler 1976).

Twelve index parents received a diagnosis of schizophrenia according to the broad diagnostic criteria and 30 parents were diagnosed as having had a serious, but not schizophrenic, psychiatric disorder.

**Apparatus**

All experiments were conducted in a shielded, sound-reduced room. Tone stimuli used in both the habituation and conditioning tasks were produced by a Heathkit Model IG 18 audio generator. The white noise utilized as the UCS in the conditioning experiment was produced by a Model 15012 Lafayette White Noise Generator. Sound levels were measured by a Model 1561A General Radio Sound Level Recorder. The timing of the stimulus duration and interstimulus intervals was controlled by Lehigh Valley solid-state equipment. Stimuli were presented to subjects via Model TDH39 Grason-Stadler headphones. Skin conductance was measured directly using a constant-voltage circuit (Lykken and Venables 1971) fed into a Grass Model 7 Polygraph with sensitivity set at .25 micromho/cm and recorded on a Vetter Model A FM tape recorder.

**Procedure**

Upon arrival, subjects were given a tour of the laboratory and shown the equipment to be used during the experiments. They selected a small gift which they received at the conclusion of the session, the experimental procedures were explained, and Beckman miniature chlorided-silver electrodes were then attached to the second phalanx of the first and second fingers of the left hand. A Unibase-saline solution served as electrolyte (Lykken and Venables 1971).

Following an initial 10-minute rest period, two experiments were conducted: (1) orientation/habituation and (2) conditioning and extinction/generalization. In the orienting/habituation experiment, 20 tones (2 sec, 1,000 Hz) at 75 dB intensity were presented binaurally. Each tone was followed by a variable 30- to 50-second interval. Subjects were instructed that they would hear sounds through the earphones, but that the sounds were meaningless and were not to be attended or responded to in any way.

After a brief rest period following the habituation experiment, the conditioning procedure was begun with the presentation of eight preconditioning stimuli: four 1,000 Hz tones at 75 dB intensity for 8 seconds' duration, and two tones each at 1,300 Hz and 2,000 Hz of the same intensity and duration. The latter two sets of higher frequency tones served as baseline measurements for the generalization stimuli (GSL and GSI) that were presented following the conditioning phase of the experiment.

The conditioning phase, which involved a modified version of Mednick's procedure, began with the presentation of the conditioned stimulus (CS), a tone (1,000 Hz, 75 dB) lasting for 8 seconds, followed immediately by a 4-second burst of white noise at 95 dB (UCS). Intertrial intervals were random, ranging from 30 to 50 seconds. A total of 20 trials were presented consisting of 14 CS-UCS paired trials interspersed in pseudorandom order with 6 CS-only trials. No specific instruction or information was given before this phase.

After a 3-minute rest period, an extinction/
generalization phase (10 trials) was conducted with four presentations of the CS alone interspersed with three presentations each of GS1 (1,300 Hz) and GS2 (2,000 Hz). All stimuli were presented at 75 dB intensity for 8 seconds with 30- to 50-second random intertrial intervals.

Results

Skin conductance responses and conductance levels were range-corrected following methods suggested for each by Lykken et al. (1966) in which response magnitudes and levels are converted to a proportion of the subject's skin conductance range. The skin conductance range was derived from the maximum and minimum values observed during the entire session. There were no significant differences in ranges between the two groups of subjects. Data from each phase (resting, orientation/habituation, preconditioning, conditioning, and extinction/generalization) were trial-blocked for the purposes of statistical analyses. For orientation and habituation the data were grouped into four blocks, each containing two successive trials, and into two additional blocks, each containing six trials, since at that point responses were minimal. For conditioning, the reinforced and unreinforced trials were blocked separately. Four blocks of three successive reinforced trials were followed by one block that contained only two trials. The unreinforced trials were grouped into two blocks of three successive trials. Data from the preconditioning and extinction/generalization phases were trial-blocked separately for CS, GS1, and GS2 trials. Each trial-block contained either two or three successive presentations of the same stimulus.

Response data from the orientation/habituation procedure were examined using a 2 (schizophrenic, nonschizophrenic) × 6 (trial-blocks) analysis of variance. A skin conductance response (SCR) was measured as the conductance change occurring within 1 to 5 seconds after stimulus onset. During trial-blocking zero scores were averaged with non-zero scores to produce response magnitude measures. Tonic levels were measured at the point of response onset, or at stimulus offset when no response occurred. Response latency was scored only when a response occurred. Spontaneous responses were defined as responses during the intertrial interval that began later than 5 seconds after stimulus onset. While typical habituation curves for magnitude of SCR were obtained for both sets of offspring (see figure 1), no differences were found between high and low risk groups either in terms of response magnitude, latency, or number of spontaneous responses (see table 1). A simple comparison of the number of trials to habituation (three successive nonresponsive trials) also failed to reveal differences between the two diagnostic groups (table 1).

Several measures of SCR magnitude and latency were assumed to reflect aspects of the conditioning process in the second experiment: (1) the reappearance of the orientation response to the CS 1 to 4 seconds poststimulus, the first-interval response (FIR); (2) a second-interval anticipatory response (SIR) 4 to 9 seconds poststimulus; and (3) a third-interval response (TIR) beginning after 9 seconds, timelocked to the scheduled appearance of the UCS. We also mea-
Table 1. Habituation: Mean number of trials to habituation, response latencies, and spontaneous responses

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<th>Low Risk</th>
<th>High Risk</th>
<th>NS</th>
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<tr>
<td>Trial habituation</td>
<td>X 7.57</td>
<td>10.67</td>
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<tr>
<td></td>
<td>SD 5.81</td>
<td>6.75</td>
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<tr>
<td>Response latency</td>
<td>X 2.05</td>
<td>1.88</td>
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<td></td>
<td>SD 0.72</td>
<td>0.59</td>
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<tr>
<td>Spontaneous response/trial block</td>
<td>X 1.18</td>
<td>1.88</td>
<td>NS</td>
</tr>
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<td></td>
<td>SD 2.46</td>
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sured half-amplitude recovery time of the response coinciding with the appearance of the UCS. The last phase of the experiment (extinction/generalization) provided data on magnitude and latency in the aforementioned response categories to repeated unreinforced presentations of the CS and to generalization stimuli along a frequency continuum.

Comparison of FIR responses during conditioning yielded evidence of sensitization. However, there were no differences between high and low risk children, nor were there any differences found between groups for SIR, and therefore these data will not be reported in detail (see figure 2). However, during the first, but not the second, block of extinction trials, high risk offspring produced a trend toward larger SIR response magnitudes than the low risk subjects \([F(1,40) = 3.12, p < .10]\) (see figure 3).

Other data from the conditioning phase produced evidence of significant differences in conditioning between the two groups of children (see figure 4). A 2 (schizophrenic, nonschizophrenic) \(\times 2\) (trial-blocks) analysis of variance for TIR magnitudes revealed that high risk offspring produced significantly larger magnitudes of SCR to interpolated unreinforced test (CS-only) trials than did the low risk offspring \([F(1,40) = 4.52, p < .04]\). However, the fact that both groups produced very low mean response magnitudes suggests a relatively weak conditioning effect, at best.

Some further support for differences in conditioning between the two groups appeared in analyses of TIR magnitudes to the CS during the extinction phase of the experiment. There was a trend toward a main effect for diagnosis \([F(1,40) = 3.90, p < .06]\) caused by the larger response magnitudes of the high risk offspring, as compared to the low risk subjects, to the CS test trials during extinction (see figure 4).

Examination of response magnitudes to reinforced trials (CS-UCS) by means of a 2 (schizophrenic, nonschizophrenic) \(\times 5\) (trial-blocks) analysis of variance indicated that offspring of schizophrenics were significantly more responsive to the UCS than were the low risk subjects \([F(1,40) = 7.57, p < .01]\) (see figure 4). A significant diagnosis \(\times\) trial-blocks interaction revealed that the differences in response magnitude between groups diminished over the course of the trial-blocks \([F(4,160) = 5.32, p < .001]\).

With respect to the generalization phase of the experiment, only one significant result emerged. The offspring of schizophrenics pro-

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\(^3\) Analyses of covariance of response magnitude data, in which conductance level was the covariate, produced identical results to those reported above, as did analyses using log transformations of the raw data.
Reduced larger SIRs to the second generalization stimulus (GS2) than nonschizophrenic offspring \([F(1,40) = 6.26, p < .02]\).

Half-amplitude recovery times (Edelberg 1970) were measured for responses during the third-interval period that occurred either to the appearance of the UCS or to its nonappearance during unreinforced test trials. Analyses of the half-amplitude recovery time did not differentiate between the two groups of children.
Figure 4. Conditioning and extinction: Third-interval response (TIR) magnitudes

(see figure 5). Correlations between half-amplitude recovery time and the corrected SCR magnitude ranged from .04 to .42; $z$ transformation of these correlations yielded a nonsignificant mean $r = .28$ across trial-blocks.

Analysis of response latencies failed to reveal any significant effects associated with parent diagnosis.

Examination of skin conductance levels (SCLs) revealed further significant differences between groups as a function of risk status. To begin with, an overall analysis of variance was performed on SCLs obtained across experiments. This included data from habituation, preconditioning, conditioning, and extinction/generalization. The results of this 2 (schizophrenic, nonschizophrenic) × 18 (trial-blocks across experiments) analysis revealed a significant interaction of diagnosis with trial-blocks across experiments [$F(17,690) = 1.98$, $p < .02$] (see figure 6). Orthogonal analysis indicated a significant linear effect in which the conductance levels of nonschizophrenic offspring increased more across the experimental session [$F(1,40) = 4.21$, $p < .05$]. Correlations between SCL and response magnitude ranged from .24 to -.46.

Discussion

Data from the orientation/habituation experiment show no differences between the high and low risk groups with respect to rate of habituation to stimuli of medium intensity. Furthermore, there are no differences between groups in the frequency of orienting responses or spontaneous responses. These data are partly consistent with Van Dyke (1972), although we were unable to replicate his finding of significantly larger electrodermal responses to nonsignal stimuli. With reference to research with adult schizophrenics, the data are inconsistent with the findings of Zahn (1964) and Zahn, Rosenthal, and Lawlor (1968) that the rate of autonomic habituation in response to moderate auditory stimuli is slower for schizophrenic adults than for normals, and with Bernstein (1964, 1967a, 1967b, and 1970), who reported more rapid ha-
The conditioning experiment yielded only partial replication of Mednick's results: high risk subjects demonstrate greater skin conductance responsivity. Given the low response magnitudes obtained, there is some, though only weak, evidence for more conditioning of the electrodermal response compared with low risk subjects. Similarly, we found only minimal evidence for greater stimulus generalization in the high risk group, and we did not replicate Mednick's finding that high risk children recover more quickly from autonomic disruption. More recently, Mednick (in press) has suggested that recovery time in offspring may be more related to the presence of hallucinations in the parents than to their diagnosis. Our own data are more consistent with results obtained by Van Dyke (1972) and Maricq and Edelberg (1975) with adult schizophrenics in that half-amplitude recovery time did not differentiate between the two groups of children.

It is important to note that our intertrial intervals ranged from 30 to 60 seconds while Mednick's ranged from 17 to 77 seconds. It is possible that the shorter intervals in the range used by Mednick might have impeded accurate measurement of the full recovery from some large electrodermal responses likely to be elicited by initial presentations of the UCS. In other analyses, Mednick has utilized a half-amplitude recovery rate that is less susceptible to the above criticism.

The evidence for greater phasic responsivity to an intense and unpleasant loud noise and the less robust evidence of greater conditioning among high risk offspring are consistent with...
two aspects of Mednick's (1966) theory—that schizophrenia is a learned disorder of thought and that there may be certain physiological factors that predispose individuals to such learning. However, our failure to obtain convincing evidence of greater generalization or more rapid recovery from states of autonomic imbalance in high risk subjects is inconsistent with Mednick's view that these latter factors are a necessary part of the complex of characteristics predisposing individuals to schizophrenia. Thus far, outcome data regarding the eventual clinical status of the children we studied are not available. Therefore we must suspend judgment as to whether all of the above factors are necessary components of a predisposition for schizophrenia or other severe psychopathology. Nevertheless, our present data are consistent with the suggestion that children at risk are likely to overreact to loud disruptive environmental stimuli, and that previously neutral cues that occur in association with such stimuli are likely to elicit similar overreactions.

The results of the comparison of conductance levels in the two groups suggest that while both groups appear to undergo a process of increasing mobilization during the session, this increase is less in the high risk than in the low risk subjects. These data are not consistent with Mednick's (in press) finding that high risk children from nonintact families showed significantly higher average SCLs over the course of his conditioning experiment than did low risk probands. Indeed, it could be argued that tonic response levels are equally as valid an aspect of "responsivity" as are phasic responses. It is necessary to qualify any reference to overall responsivity among high risk children by noting that, so far as our data indicate, they are more responsive in one sense (phasic) and less so in another (tonic levels). Such apparent inconsistency, however, has also been noted elsewhere (Van Dyke, Rosenthal, and Rasmussen 1974). Zahn (1977) has pointed to the tendency for low tonic reactivity
to task-produced stress to be characteristic of biological parents of schizophrenics, and raises the question of a predisposing genetic factor.

While the literature on SCL with adult schizophrenics indicates inconsistent results (Depue and Fowles 1973, Stern and Janes 1973, and Venables 1975), the lower SCLs in our high risk group during the conditioning experiment may reflect less of an arousal response to the experimental contingencies in that procedure. Fenz and Steffy (1968) related a measure of social responsiveness to SCLs and found higher levels to be correlated with the amount of appropriate social behavior. Socially responsive subjects were more responsive to task demands in an experimental situation in that they demonstrated increases in SCL during the period of the experiment, while socially nonresponsive subjects produced decreases in SCL.

The sequence of experiments in the session in which our skin conductance measures were taken progressed from a resting period to a rather mild orientation/habituation experiment to a more intense and unpleasant conditioning procedure. Examination of the data revealed the presence of a crossover in SCL between high and low risk groups as they completed these procedures. In the light of these findings, the significantly greater phasic reactivity of the high risk group during conditioning is of interest since it suggests the possibility that a failure to become more tonically "aroused" to the experimental contingencies is associated with a tendency to react in a more labile fashion to the appearance of the loud noise. Put simply, it suggests that when subjects are less alert to the nature of the experimental situation, they are more likely to overreact to the appearance of the disruptive stimulus. These differences in reactivity are more apparent in the early trial-blocks of the conditioning experiment. Eventually, both groups habituate to the UCS to the point where little difference in phasic responses is apparent between the groups. Possibly, the tendency to react more strongly to the appearance of the UCS is a factor which facilitated the somewhat greater conditioning in the high risk group.

Finally, it is important to note that these results were obtained from a sample of high risk children that differed in important ways from Mednick's sample. Parents who received the broad criterion diagnosis of schizophrenia in our sample included patients who would not be regarded as "severe and typical schizophrenics" (Mednick 1971, p. 271). Our high risk parents were not required to meet Mednick's rigorous criteria, including at least 5 years of hospitalization, three separate periods of hospitalization each of which was of at least 3 months' duration with no sign of improvement during discharge, or an extended single hospitalization. Some of our schizophrenic parents were diagnosed as having schizoaffective disorders and the schizophrenic group was hospitalized for an average of only 23 weeks. Furthermore, there was little or no incidence of criminality among the fathers of high risk children, nor did we find as high an incidence of psychiatric disturbance among the spouses of our index parents as was reported by B. Mednick (1973) for S. Mednick's "breakdown" (sick) group. In Mednick's sample it appears likely that there were a number of dual schizophrenic matings in the "sick" group, and that a large number of the children who broke down subsequent to Mednick's initial examination had no mother or mother substitute during their early childhood. In contrast, all of our children came from intact families in which the parents and child lived together.

Apart from differences in the parents, our children were studied at age 10 in contrast to a mean age of 15.1 years in the sample studied by Mednick. It is of some importance that we are able to find differences between high and low risk children by age 10, as this may point more clearly to possible genetic contributions to the autonomic sensitivity of these high risk children. In contrast to some of Mednick's children who were already beginning to enter the age of risk for the initial onset of schizophrenic disturbance, thus far our children remain functional in both home and school settings without evidence of serious emotional disturbance.

It remains difficult to account for the discrepancies between our results and those of other researchers. The accumulation of conflicting data may be the product of the considerable
sampling and methodological differences observable across studies, and it underscores the importance of further replication. Several interesting areas of inquiry for further research with high risk groups might also employ tasks involving more meaningful stimuli, or variations in the demand characteristics of the task, or in the complexity of the required response.

Summary

Measures of skin conductance during rest and during experiments testing habituation and conditioning of the skin conductance response were obtained from 42 10-year-old male children, of whom 12 were at risk for schizophrenia and 30 constituted low risk controls. While typical habituation curves for skin conductance response were obtained from both sets of offspring, no differences were found between high and low risk subjects on trials to habituation, response magnitude, latency, or number of spontaneous responses. However, there was evidence suggestive of differential conditioning in the two groups of children as a function of risk status. High risk offspring produced significantly larger skin conductance responses to conditioning test trials than low risk offspring. High risk subjects were also significantly more responsive to the unconditioned stimulus (loud white noise) than low risk subjects, but half-amplitude recovery time did not differentiate between the two groups of children. Finally, high risk offspring manifested lower levels of tonic conductance during conditioning, but not during resting or habituation. These results lend support to two important recent findings by Mednick concerning autonomic differences between high and low risk children, but do not confirm his findings regarding generalization and half-amplitude recovery time.

References.


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The Authors

Leonard F. Salzman, Ph.D., is Professor of Psychiatry and Psychology, Department of Psychiatry, Division of Psychology, University of Rochester School of Medicine and Dentistry, Rochester, N.Y. Robert H. Klein, Ph.D., is Associate Professor of Clinical Psychiatry, Department of Psychiatry, University of Pittsburgh School of Medicine, Pittsburgh, Pa.

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