Skin Conductance Habituation in Panic Disorder Patients

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Skin conductance habituation was compared between 38 patients meeting DSM-III criteria for Panic Disorder and 29 normal controls. Approximately half of each group was randomly assigned to be given 100 dB SPL tones and the other half 75 dB tones. All indices pointed to slowed habituation in patients compared with normals: number of trials to response habituation, total number of responses, and slope of decline of skin conductance level. Patient-normal differences were not significantly larger for 100 dB than for 75 dB. In addition, patients compared with normals had more nonspecific fluctuations, higher skin conductance levels, and a shorter response latency to the first stimulus. Stepwise discriminant analyses classified patients and normals better in the 100 dB than in the 75 dB condition, and showed that the various skin conductance variables were largely redundant at the higher intensity.

Autonomic measures of emotional reactivity have been widely applied to the study of schizophrenia, depression, and anxiety disorders (see Zahn 1986, for a review). Not surprisingly, patients with phobias tend to react autonomically more to actual (Nesse et al. 1985; Roth et al. 1986) or symbolic (Fredrikson 1981; Dimberg et al. 1986) confrontation with their phobic objects than normal controls do to the same objects. More controversial, however, is whether anxious patients are generally more autonomically reactive, responding more than normals to nonphobic stimuli. According to Gray (1982), a major class of input to the "behavioral inhibition system," the neurophysiological substrate of anxiety, is novel stimuli of any kind. Novel stimuli produce a complex of reactions called the orienting response (Sokolov 1963), which does not depend on learned associations with aversive events. In humans, the skin conductance response (SCR) is a sensitive component of the orienting response. Thus, SCRs to novel stimuli in an orienting response paradigm might show unusual magnitude or persistence in patients with anxiety disorders.

A principal characteristic of SCRs is a decrement in response amplitude with repetitions of the same stimulus, a phenomenon called habituation. Lader and Wing (1964) found that clinically anxious patients, with the exception of those with specific phobias, showed slower SCR habituation, higher rates of nonspecific fluctuations (NSFs), and higher skin

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Table 1. Skin Conductance Response Habituation to Nonphobic Stimuli in Anxiety Disorder Patients

Reference	Diagnoses	Stimuli (type, intensity, duration)	ISI (s)	Results
Stewart et al. 1959	AN, S, B, PD	Tones, 65 dB HL, 4 s	30–160	A < S; A < B; A = PD (no normal comparison group)
Tan 1964	Mixed disorders, with anxiety	Tones, "about" 65 dB, 4 s	Mean = 20	A = N
Lader and Wing 1964	Anxiety states	Tones, 100 dB SPL, 1 s	45–80	A < N
Lader 1967	Simple phobia, social phobia, agoraphobia, anxiety state, anxiety + depression	Tones, 100 dB SPL, 1 s	45–80	A < N except for simple phobia
Hart 1974	AN, anxiety state	Tones, 50, 75, 100 dB interspersed, 2 s	35–65	A = N
Raskin 1975	Various anxiety disorders	Tones, 100 dB, 1 s	45–80	A < N
Horvath and Meares 1979	Anxiety states, C, P, NP	Tone, 100 dB, 1 s	15–80	A < N; C < N P = C; NP < N
Chattopadhyay et al. 1980	"Primary anxiety states"	Flashes, 9×10^5 candles/m^2,10 μs	15–25	A = N
Frith et al. 1982	AN, DN, S	Tones, 85 dB, 1 s	15–25	A < DN; A = S; DN = S
Roth et al. 1986	Agoraphobia + panic attacks (DSM-III)	Tones, 75 dB SPL, 1 s	12–17	A = N
Orr and Pitman 1987	Various anxiety disorders (DSM-III)	Tones, 86 dB SPL, 0.5 s	30–60	A = N
Kopp et al. 1987	Various anxiety disorders (DSM-III)	Tones, 65 dB, 1 s	15–25	A = N

A = anxiety disorder patients of diagnosis/diagnoses indicated; N = normals; s = sec; SPL = sound pressure level; HL = normal hearing level; m = meter; S = schizophrenia; B = bipolar-depressed; PD = personality disorder; C = conversion; AN = anxiety neurosis, P = paranoid schizophrenia; NP = nonparanoid schizophrenia; DN = depressed neurosis.

conductance levels (SCLs) than normals. NSF rates and SCLs were considered to be reflections of generalized "arousal," which at higher levels is experienced subjectively as anxiety. On the basis of these observations, Lader and Mathews (1968) went on to postulate that in anxious patients a vicious circle might ensue, in which slower habituation to repeated, naturally occurring stimuli could lead to increased levels of arousal, which in turn would further retard habituation to subsequent stimuli. This process could escalate with explosive, attack-type rapidity to very high arousal levels. As an explanation for panic attacks, this theory is a noncognitive version of more recent vicious circle theories (e.g., Margraf et al. 1986). Unfortunately for Lader and Mathews' (1968) theory, however, the results of published studies of SCR habituation to nonphobic stimuli in anxiety disorder patients often are inconsistent with those of Lader and Wing (1964), as noted in Table 1. Considering the studies that used tone stimuli and a normal comparison group, there is a suggestion of a pattern, first noted by Öhman (1981), that anxious patients have normal habituation to moderate intensities but slower habituation to higher intensities. The experiment of Hart (1974) is not really an exception as the 100 dB stimuli were not given sequentially, but interspersed with lower intensity stimuli, which may have speeded habituation. A pattern that differs for higher and lower intensity stimuli is consistent with the theoretical and empirical distinction between orienting and defense responses (Sokolov 1963; Graham 1979). Clinically, tones of an intensity that elicit orienting responses are

better able than loud tones to distinguish schizophrenics from normals; normals are much more likely than schizophrenics to respond with orienting responses (Öhman 1981; Bernstein et al. 1982). Anxious patients may be different from normals in continuing to respond to tone intensities that are aversive enough to elicit defense responses. Another possibility, of course, is that diagnostic inhomogeneity within and between studies, particularly in earlier ones where diagnosis was less standardized, could lie behind the discrepancies in results. In our experiment (Roth et al. 1986), the failure to demonstrate slower habituation might have been a special feature of patients with a phobia (agoraphobia) based on panic attacks.

We report here what is to the best of our knowledge the first study to randomly assign anxiety patients with a uniform research diagnosis, namely, panic disorder, to stimulation with either moderate or high intensity stimuli. Thus, a comparison within the same patient population could be made between novel and moderately aversive nonphobic stimuli. On the basis of our review of the literature (Table 1), we hypothesized that SCR habituation to higher intensity stimuli would be slower in patients than in normals but habituation to moderate intensity stimuli would be the same in both groups.

Methods

Subjects

Fifty-seven patients with panic disorder were recruited through the media for a study comparing the effects of alprazolam, imipramine, and placebo. All met DSM-III criteria for panic disorder or agoraphobia with panic attacks as determined by the Structured Clinical Interview of DSM-III Upjohn Version (SCID-UP) (Spitzer and Williams 1983). Additionally, patients had to have had at least one attack in each of the 3 weeks before entering the study. Any major depressive episodes in the present or past needed to follow and not precede the panic attacks. All subjects had to be in good health as determined by medical history, physical examination, electrocardiogram (ECG), and blood and urine tests. Patients were told to stop taking psychoactive drugs 2 weeks before testing, and blood was drawn for levels of tricyclic and benzodiazepine derivatives at the laboratory session to insure that they followed instructions. Twelve patients were excluded because of detectable levels of these compounds or because of self-reported use of drugs (prescription, over-the-counter, or "recreational") that might influence our measures during the previous 4 days. Women were not excluded for using estrogens postmenopausally or contraceptive pills. Two patients were dropped because of their failure to pass our hearing criterion of having 1000 Hz thresholds less than 15 dB above normal in both ears. Of the remaining pool of 43, 38 patients were selected without regard to their test results, who could be age- and gender-matched with our normal group.

Normal controls were recruited by newspaper advertisement. They were preliminarily screened over the telephone and then in structured interviews. All described themselves as "nonanxious" and were free of a history of psychiatric problems as determined by the SCID-UP and a structured interview based on the Schedule for Affective Disorders—Schizophrenia-Lifetime Version (SADS-L) (Spitzer and Endicott 1978). Anyone with significant health problems was rejected. In later phases of control recruiting, we excluded potential subjects who engaged in regular, strenuous exercise for fear they would be outliers on cardiovascular measures recorded in stress tests to be reported elsewhere. Thirty-one normal controls passed this screening. None was rejected for poor hearing.

Table 2. Group Composition

	75 dB		100 dB	
	Patients	Normals	Patients	Normals
Number—Total	21	15	17	14
Men	5	3	5	4
Age	36.1	36.2	34.1	34.7
STAI/S	41.5	26.9	39.6	31.2
STAI/T	50.0	30.2	49.5	33.1
BDI	6.6	0.7	7.7	2.0

STAI/S = State Trait Anxiety Inventory/State Form; STAI/T = Trait Form; BDI = Beck Depression Inventory.

Two were later dropped because of self-reported drug use prior to testing, giving a final group of 29.

Table 2 summarizes some clinically relevant characteristics of the four groups. The Spielberger State Trait Anxiety Inventory/Trait Form (STAI/T) was given shortly before a baseline period at the beginning of the testing session, and the State Form (STAI/S) shortly after the beginning of the session (Spielberger et al. 1970). The brief version of the Beck Depression Inventory (BDI) (Beck and Beck 1972) had been administered on a previous day.

Of the 38 patients, 9 had no agoraphobic avoidance, 23 had limited avoidance, and 6 had extensive avoidance. They had had panic disorder for an average of 8.5 (SD = 9.0) years, and reported an average of 1.8 (2.1) spontaneous and 2.8 (2.8) situational or minor symptom attacks in the week prior to testing. Twenty-one had additional psychiatric disorders: 12, major depressive episodes; 2, dysthymia; 6, social phobia; and 8, simple phobia. (A patient could receive more than one additional diagnosis.)

Procedure

At the beginning of the session, a pair of Ag/AgCl disc electrodes 0.8 cm^2 in area was placed on thenar and hypothenar eminences of the nondominant hand for recording skin conductance. The electrode medium was a mixture of creamy ointment and physiological saline as recommended by Fowles et al. (1981). The skin conductance transducer applied a constant 0.5 V across the electrodes. Testing took place in a sound-attenuated chamber where subjects could not see laboratory personnel while the paradigms were being run, but could communicate with them by intercom. Subjects had been in this chamber with the electrodes in place about 1 hr before the habituation paradigm was run. During that time, they had undergone the following tests: baseline (15 min), heart rate matching task (1 min), Stroop color-naming (15 min), adaptation to wearing a gas mask (6 min), and hyperventilation (6 min). After a break of a few minutes after the last task, subjects were given written instructions for the habituation paradigm, which stated that they would hear a series of tones at random time intervals, but that they need not do anything, nor would they later be queried about the tones. They were to sit quietly with their eyes open while the tones were being presented.

The habituation paradigm was similar to other orienting response paradigms used in studies of psychiatric patients (Öhman 1981; Bernstein et al. 1982), and is identical to

the one used by Roth et al. (1986) in a study of agoraphobics, except for the addition of a 100 dB stimulus condition. Nineteen 1-sec tones were given with random interstimulus intervals distributed uniformly over a 24–45 sec range. Rise and fall times of the tones were 25 msec to avoid startle responses. All tones were 1000 Hz except tone 17, the dishabituating tone, which was 600 Hz. The paradigm was given in two versions: one in which all tones except tone 17 are 75 dB sound pressure level, and tone 17 is 70 dB, and another in which all tones except 17 are 100 dB, and tone 17 is 95 dB. Making the dishabituating tone less intense as well as different in pitch increases its deviancy and guarantees that larger SCRs to it are not a result of greater stimulus energy from improper intensity matching.

Before and after the paradigm, subjects filled out previously developed anxiety rating scales (Ehlers et al. 1986), going from 0 (no anxiety) to 10 (extreme anxiety).

Psychophysiological Data Reduction

Evaluation of the electrodermal measures followed that of Roth et al. (1986) to insure comparability with that study. Skin conductance was sampled every 5 msec, and these samples were averaged in groups of 10 (50 msec) and stored. SCL was recorded at the 50 msec point immediately before each stimulus. NSFs were defined as requiring an increase of SCL of 0.05 microsiemens (μS) occurring within 3.5 sec after a change in SCL slope of at least 0.01 μS/sec from negative or zero values to a positive value. The time point where the change in slope first meets this criteria is the onset point. The number of NSFs occurring in all 17 sec prestimulus epochs was used to calculate an average NSF/min rate for the entire paradigm. SCRs were defined as requiring an onset point as defined for NSFs 1.0–4.0 sec after stimulus onset and an amplitude reaching 0.05 μS within 3.5 sec after this point. The number of SCRs to habituation was the number of responses before three consecutive failures to response. As trial 17 was designed to be dishabituating and to elicit orienting response recovery, this measure was only calculated to trial 16. Some subjects did not habituate by trial 13, the last trial that would allow three more nonresponse trials, and they were scored as habituating on the last trial on which they responded, up to trial 16. In one analysis these subjects were called nonhabituators. A second measure of SCR habituation, SCR magnitude slope, was calculated by the method of Lader and Wing (1964), for which the parameters of the linear regression line relating log SCR magnitude and log trial number were determined for each subject beginning with trial 2 and ending with the third consecutive failure to respond. (SCR *magnitude* measures include zero values or failure to respond, whereas SCR *amplitude* measures exclude zero values.) In addition, for SCRs, the amplitude, rise time, peak latency, one-quarter recovery time, one-half recovery time, and the ratio, (number of SCRs/min)/(NSFs/min + 1) were calculated. Recoveries longer than 10 sec were considered invalid and treated as missing data.

Statistical Analysis

Multivariate and univariate analyses of variance (MANOVAs and ANOVAs) were done in order to look simultaneously for effects of Group (patients or normals) and Intensity (75 or 100 dB). Following the recommendations of Venables and Christie (1980), SCL and SCR were log-transformed prior to statistical analysis. Stepwise discriminant analyses

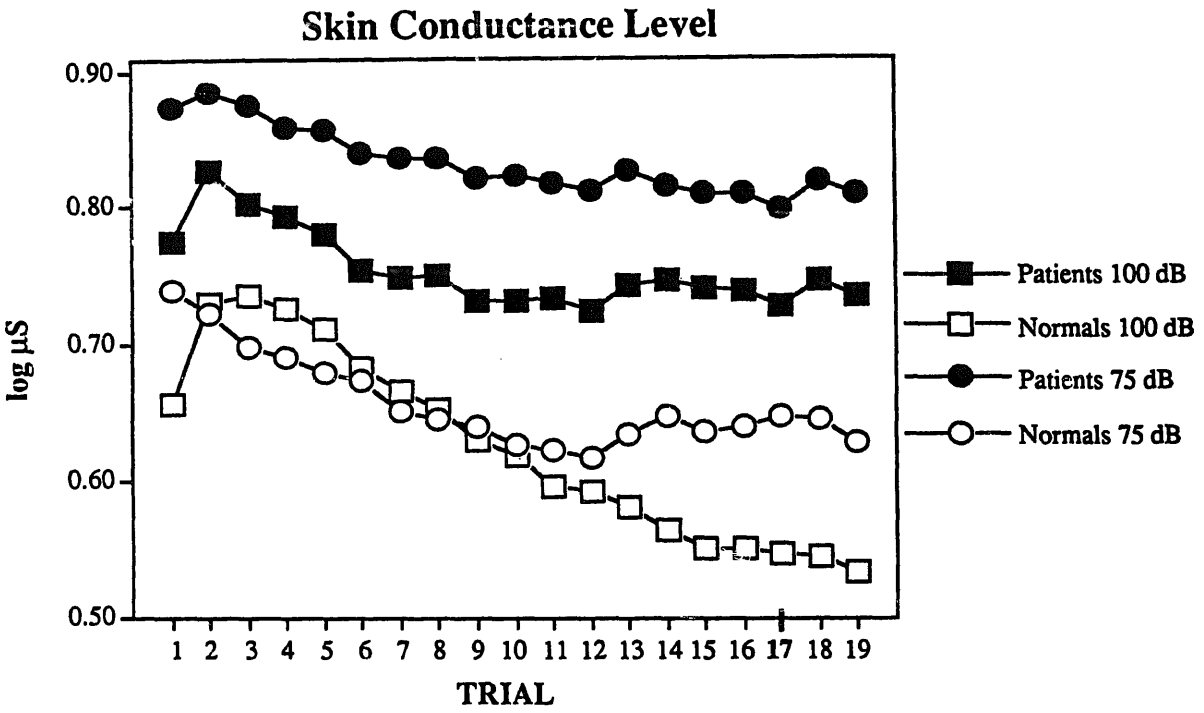

Figure 1. Log skin conductance level over trials for patients and controls in the 75 dB and 100 dB stimulus conditions.

(BMPD program 7M) tested how well groups could be distinguished by our measures. Product-moment correlations were calculated among measures showing group effects, the subjective anxiety rating, and the score on the Beck Depression Inventory.

Results

Figure 1 is a graph of SCL over trials. A decline in level is seen in all groups but is slower for patients, i.e., patients had a flatter slope. In addition, overall SCLs of patients are greater than those of normals. Figure 2 is a graph of SCR magnitude over trials. Habituation occurs in all subject groups but appears slower in patients than in normals and with 100 dB compared to 75 dB stimuli. A MANOVA of the three primary habituation measures—trials to SCR habituation, total number of SCRs, and SCL slope—showed significant Group ($F(3,61) = 3.51, p < 0.05$) and Intensity ($F(3,61) = 3.37, p < 0.05$) effects, but an insignificant Group × Intensity interaction ($F(3,61) = 1.29, p > 0.29$). Slope SCR could not be included in this analysis because of missing data for subjects that had no or just one response. A second MANOVA of the two primary general activation measures—log SCL and NSF/min—showed a significant Group effect ($F(2,62) = 3.39$, $p < 0.05$) but insignificant Intensity ($F(2,62) = 0.25, p > 0.78$) and Group × Intensity ($F(2,62) = 1.89, p > 0.15$) effects.

Table 3 shows means and univariate statistical analysis of our electrodermal measures. Variables included in the MANOVAs manifested by univariate analysis the same patterns of significance, except for SCL slope, which showed no Intensity effect. Analyses of covariance of SCL slope using SCL level before the first stimulus or *y*-intercept as covariates gave the same significant Group difference as without this adjustment. At 100

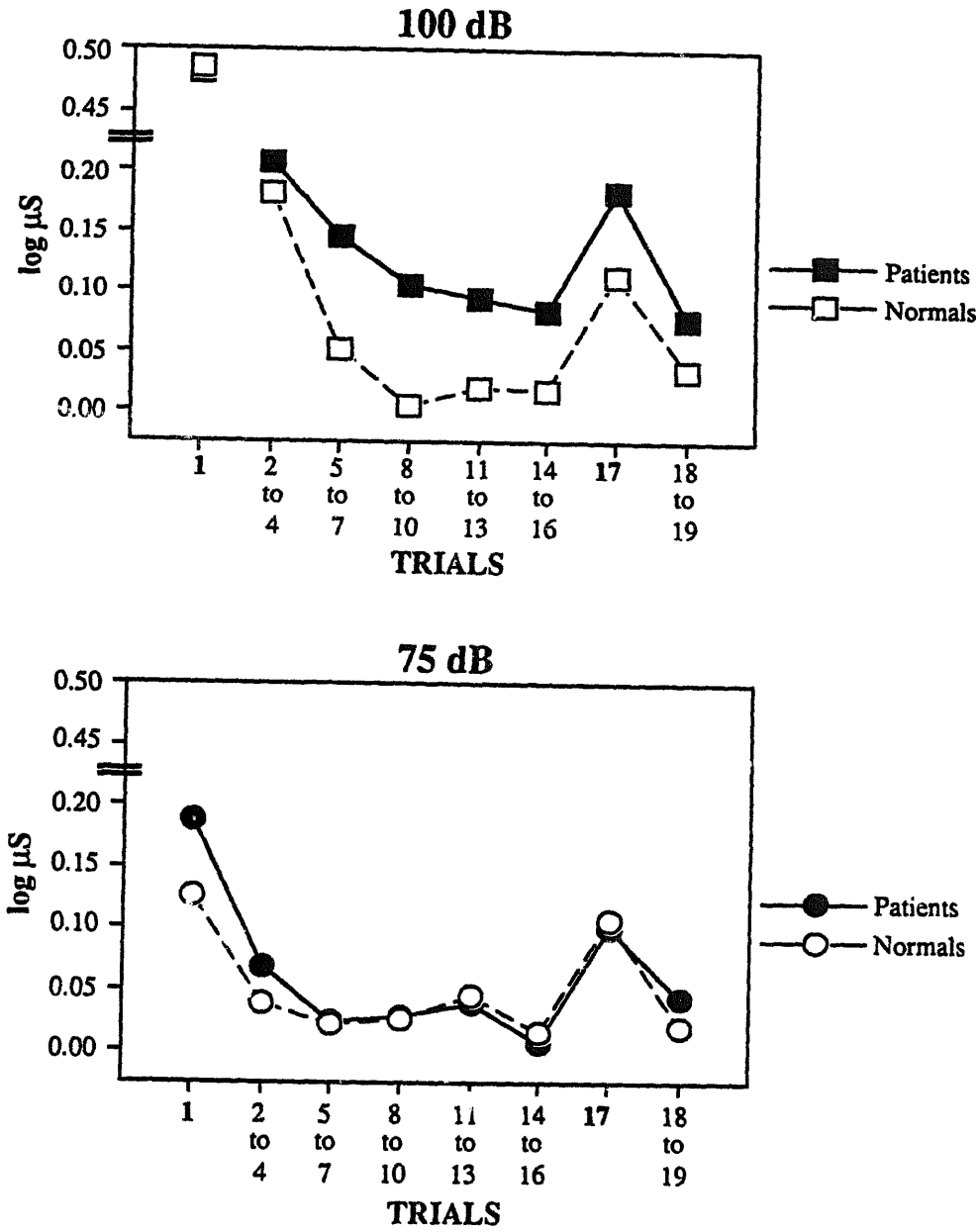

Figure 2. Log skin conductance response magnitude (which includes zero responses) over trials for patients and controls in the 75 dB and 100 dB stimulus conditions. Except for trials 1 and 17, trials are averaged in groups.

dB, 7 patients but no normals were nonhabituators, a significant difference (χ^2 (1) = 7.45, $p < 0.01$), whereas at 75 dB, all subjects habituated. The number of complete nonresponders was low and did not distinguish the groups (no patients versus 1 normal at 100 dB and 5 patients verus 3 normals at 75 dB). Because Levinson and Edelberg (1985) advocated a criterion of two rather than three no-response trials for habituation (cf. Vossel and Zimmer 1988), we also analyzed trials to habituation this way and found by ANOVA even more significant Group ($p < 0.002$) and Intensity effects ($p < 0.004$), but the Group × Intensity interaction remained nonsignificant ($p = 0.20$). Reducing the

Table 3. Means and Significance Levels of Electodermal Measures

Variable	Trials	75 dB		100 dB		Significance levels		
		Patients	Normals	Patients	Normals	Group	Intensity	G × I
SCL								
Level	1–16	7.4	4.6	5.8	4.8	[a]	—	—
Slope	1–16	−0.10	−0.13	−0.09	−0.20	[a]	—	—
NSF	1–16	2.3	1.6	2.5	0.8	[a]	—	—
SCR								
n to habituation	1–16	4.0	3.0	8.7	4.2	[a]	[a]	—
Total n	1–19	5.2	4.4	9.6	6.0	[a]	[b]	—
Magnitude	1	0.76	0.44	2.81	2.56	—	[c]	—
Magnitude	17	0.37	0.37	0.67	0.34	—	—	—
Magnitude slope	2+	−0.23	−0.14	−0.34	−0.66	—	[b]	[a]
Amplitude	1	1.08	0.62	2.81	2.85	—	[c]	—
	2–16	0.33	0.41	0.71	0.66	—	[a]	—
Latency	1	1.85	2.21	1.81	2.00	[a]	—	—
	2–16	2.31	2.25	2.11	2.26	—	—	—
Rise time	1	2.22	1.82	2.49	2.69	—	[a]	—
	2–16	1.61	1.78	1.76	1.93	—	—	—
0.25	1	1.13	1.05	1.49	1.28	—	—	—
Recovery	2–16	0.61	0.66	1.03	1.18	—	[a]	—
0.50	1	1.76	2.48	1.57	3.69	—	[a]	—
Recovery	2–16	1.01	0.94	1.76	2.29	—	[a]	—
n SCR/NSF	1–16	1.7	2.0	3.1	3.7	—	[b]	—

[a] $p < 0.05$; [b] $p < 0.01$; [c] $p < 0.001$; —, NS.
SCL = skin conductance levels; NSF = nonspecific fluctuations; SCR = skin conductance responses.

1–4 sec window length for SCRs to 1–3 sec had almost no effect on our data and their significance. Finally, as an alternative to our linear regression slope measure of habituation, we averaged SCR magnitudes into five groups of three trials beginning at trial 2 and performed a MANOVA. Consistent with the other analyses, the Group × Intensity × Trials interaction (analogous to Group × Intensity for slope measures) was not significant ($F(4,60) = 0.82$).

Only in the case of slope of response magnitude was there a significant Group × Intensity interaction, which reflected a slower decline for patients at 100 dB and for controls at 75 dB according to the residue analysis of Rosnow and Rosenthal (1989). An analysis of covariance with log SCL before stimulus 1 as a covariate did not alter the statistical conclusions, but with intercept as a covariate following Lader and Wing (1964), the significance of the Group × Intensity interaction slipped to $p < 0.06$ and the Intensity effect disappeared, but a significant Group effect emerged (normals having steeper slopes than patients, $p < 0.05$). A drawback of this slope measure was that in the 75 dB condition, 6 normals and 10 patients did not react with the minimum of one SCR in trials 2–4 required for its calculation and so had missing data on this measure.

SCR to stimulus 17 was not different for patients and normals, but was larger than the response to stimulus 16 (repeated measures ANOVA of stimulus 16 and 17 showed a stimulus effect, $p < 0.001$, but no Intensity or Group effects). Intensity increased SCR amplitude and rise time to the first stimulus, and slowed one-quarter and one-half recovery time. Patients reacted more quickly to the first stimulus than normals. Unfortunately, up

Table 4. Stepwise Discriminant Analysis for Each Intensity

	F-to-Enter (minimum 4.0 to proceed)		
	Step 0		Step 1
Variable	75 dB	100 dB	100 dB
Log SCL level	3.46	1.12	0.61
SCL slope	0.52	4.28	0.78
NSF	0.99	8.26	Entered
n to habituation	0.64	5.69	0.15
Total n	0.46	3.99	0.95

For 100 dB, 74% correct classification at step 0 (55% is chance level).

to one-half of the subjects had missing data on the stimulus 1 rise time and recovery measures because of gaps in the SCRs caused by large responses exceeding amplifier range at initial gain settings of the transducer.

As seen in Table 3, patients had more NSFs than normals. The SCR/NSF ratio did not differ between groups but was larger at the higher stimulus intensity.

Table 4 shows the results of a stepwise discriminant analyses done separately for each intensity with five representative measures. SCR magnitude slope had too many missing cases to be included. Classification was possible only at 100 dB. Twelve of 17 patients and 11 of 13 normals were classified correctly. As can be seen from the reduction of all Fs-to-Enter at step 1, electrodermal measures are intercorrelated. Correlations done separately for patients and normals at each intensity showed particularly high correlations between log SCL and NSFs ($rs > 0.69$, $ps < 0.01$, in all four cases). In the patients but not normals, NSFs correlated highly with total SCRs ($rs > 0.63$, $ps < 0.01$) and less highly with trials to habituation ($rs > 0.47$, $ps < 0.05$). In patients at 100 dB, log skin conductance level correlated highly with trials to habituation ($r = 0.87$, $p < 0.01$). There were no significant correlations between anxiety or Beck Depression Inventory (BDI) ratings and skin conductance measures.

The results of the stepwise discriminant analysis imply that significance of Group effects in the multivariate and univariate analyses depended much more on the 100 dB than on the 75 dB condition. For example, if trials to habituation is analyzed separately for each intensity, the Group difference at 100 dB is significant at the $p < 0.02$ level ($t(25.36) = 2.52$) but at 75 dB is far from significance ($t(32.32) = 0.88$, $p < 0.39$). Conventional strategies of hypothesis testing, however, would not permit testing at separate intensities unless Group × Intensity interactions were significant.

Subjective anxiety analyzed by ANOVA for the different groups and intensities before and after the paradigm showed only a Group effect ($p < 0.001$), patients being generally more anxious (mean = 2.88) than normals (mean = 0.62).

Discussion

The pattern of results we obtained—higher and more slowly declining SCL levels, more NSFs, and more slowly habituating SCRs to discrete stimuli—confirms the studies of Lader and Wing (1964), Lader (1967), Raskin (1975), and Horvath and Meares (1979). This pattern is different from the electrodermal pattern found in other psychiatric disorders: schizophrenics are characterized by a higher percentage of nonresponders than normals

(Öhman 1981; Bernstein et al. 1982), and euthymic previously depressed patients by generally reduced tonic levels and phasic reactivity (Iacono et al. 1983; Iacono et al. 1984), although the influence of medication has not always been adequately excluded.

Our present success in demonstrating slower SCR habituation in patients when we (Roth et al. 1986) and others (see Table 1) had previously failed, is in all likelihood the consequence of including 100 dB stimuli. We cannot claim to have conclusively proved our hypothesis that SCR habituation would be slower in patients only with high intensity stimuli, as this pattern was statistically confirmed only for slope SCR magnitude derived from the work of Lader and Wing (1964). There was no Group × Intensity interaction for trials to habituation or total number of SCRs. One reason for the nonsignificant interactions was that for both intensities, patients differed from normals in the same direction. On the other hand, there were several indications that our hypothesis is true: There was an interaction for slope SCR magnitude, and trials to habituation and total number of SCRs both had higher Fs-to-Enter in the discriminant analysis in the 100 dB than in the 75 dB condition.

As in Lader and Wing (1964) and Roth et al. (1986), SCL was generally higher in patients than in normals and declined more slowly. SCL and SCL slope would not be expected to be influenced by intensity as much as SCRs as they were measured prestimulus, and indeed they were not. They did not rebound significantly after stimulus 17 either, evidence that SCL decline had a somewhat different meaning than smaller or less probable SCRs, which represent habituation to discrete stimuli. SCL decline can indicate habituation to the testing chamber and to the paradigm in general, or a general reduction of arousal or wakefulness. However, the redundancy of variables in discriminating patients from controls and the high intercorrelations between SCL and NSFs (and, in the patients, total SCRs) suggest the existence of a unitary factor of electrodermal activation encompassing both tonic and phasic measures, and both stimulus-dependent and stimulus-independent measures.

Whether these electrodermal differences are state or trait differences is not determinable from this study or previous ones because this distinction presumes testing anxiety disorder patients when they are anxious and when their anxiety has remitted. Electrodermal variables have been demonstrated to register trait rather than state differences in depressed patients (Iacono et al. 1983; Iacono et al. 1984). As our patients were more anxious than their controls when tested, electrodermal differences between the groups could well have been state related. It is plausible, for example, that the higher SCLs and greater numbers of NSFs simply are reflections of an anxious state, as increases in these variables are observed when normals are submitted to laboratory stressors. The lack of significant between-subject correlation between subjective anxiety and electrodermal variables in this study does not argue for trait differences, as such correlations are usually low. This is a general problem for measures of activation, leading to a questioning of the validity of the concept, and must stem from innate differences unrelated to anxiety demonstrated in twin studies (Lykken et al. 1988).

Our habituation paradigm followed an hour of testing, raising the possibility that some of our results were due to slower adaptation or greater activity to previous procedures on the part of the patients. However, a previous study in our laboratory found that agoraphobic panickers have higher SCLs than controls throughout a session of this length, the difference being slightly greater at the beginning than at the end (Roth et al. 1986). SCL increases produced by a hyperventilation procedure more intense than that performed by our subjects returned to prestress levels within 7 min, a time similar to the interval

between our hyperventilation and habituation tests (Margraf et al. 1988). Overall, the most likely effect of the hour of testing was to slightly attenuate group differences.

Our results are again (Roth et al. 1986) not in line with expectations from Gray's theory (Gray 1982), but they do give some support to the model of Lader and Mathews (1968). Contrary to Gray's theory, more purely novel 75 dB tones elicited quite similar reactions in anxious and nonanxious subjects, whereas aversive 100 dB tones gave different ones, as illustrated in Figure 2. In accordance with Lader and Mathews, we found indications that patients with higher SCLs had slower SCR habituation to 100 dB tones and that the same relationship was present when patients as a group were compared with normals as a group. However, against the Lader and Mathews model of a vicious circle between slower habituation and escalating SCL and anxiety levels, tone intensity did not affect SCL habituation rate or subjective anxiety. Of course, sounds louder than 100 dB and more temporally unpredictable than ours might lead to more positive feedback, although it is unlikely that tones can ever be a provocation of panic anxiety. Panic attack patients do not typically complain of noise as an elicitor of panic or even of increased sensitivity to noise, suggesting that other more specific exogenous or endogenous provocations are necessary. Along the line proposed by Lader and Mathews (1968), sufficiently provocative stimuli, if continued or repeated, could lead to an ascending spiral of activation fueled by increasing sensitivity to those stimuli, culminating in a full-blown panic attack.

It should be noted that vicious circle theories are theories of within-subject longitudinal relationships, whereas much of the evidence used to test them comes from between-subject cross-sectional designs. Future experiments should test the same subjects at different arousal or anxiety levels. Furthermore, the same subjects could be tested for habituation at different tone intensities, thus allowing statistical control for between-subject variance irrelevant to stimulus intensity effects. This approach could lead to Order effects and Group × Order interactions, but would increase the statistical power of the design.

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