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Chronic Schizophrenic Disorder

I. Psychophysiological Responses, Laterality and Social Stress

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Bilateral palmar skin conductance and heart rate were measured throughout a series of psychological tests and during both sitting and ambulant social interactions in 14 right-handed men with chronic schizophrenic disorder and 12 healthy volunteers matched for age and handedness. Miniature radio telemetry equipment was used to collect the physiological data. The schizophrenic group was effectively unresponsive to 70-dB auditory stimuli, while all but one of the control group responded and habituated to a nil response by the tenth tone in sequence. The schizophrenic group showed some evidence of increased skin conductance activity at rest, and in socially demanding conditions skin conductance level and variability were increased in the right hand. The present group of electrodermal 'non-responders' was not in general autonomically under-active. Asymmetry of skin conductance activity during social interaction may be a characteristic of chronic schizophrenic disorder.

A number of theories concerning schizophrenic symptom formation have implicated arousal as an important source of primary dysfunction or as a factor involved in exacerbation of the disorder (Kasanin, 1932; Mednick, 1958; Fish, 1961; Lynn, 1963; Venables, 1968; Mirsky, 1969; Ax *et al*, 1970; Epstein & Coleman, 1970; Flekkoy, 1975; Lapidus & Schmolling, 1975; Farley, 1976). The evidence concerning a possible arousal dimension and schizophrenic disorder has remained contradictory with many findings to suggest either excessive or reduced physiological activity (Lynn, 1963; Depue & Fowles, 1973; Jordan, 1974; Venables, 1977; Bernstein *et al*, 1981; Gruzelier & Manchanda, 1982).

One possible explanation for the conflicting evidence, suggested by old and recent reports (Gruzelier & Venables, 1972, Venables, 1977; Gruzelier & Manchanda, 1982), is that in schizophrenic groups there is a bimodal distribution of physiological responsiveness, particularly to low intensity stimuli. Although some attempts to replicate this finding have been largely unsuccessful (Toone *et al*, 1981; Zahn *et al*, 1981), much evidence has supported it (Depue, 1976; Patterson, 1976; Deakin *et al*, 1979; Straube, 1979; Bernstein *et al*, 1981). Several studies suggest that in schizophrenic groups electrodermal responsiveness to tones reflects general physiological, and possibly emotional, responsivity (e.g. Gruzelier & Venables, 1972, 1974; Gruzelier, 1976; Straube, 1979).

Another possible reason for the lack of conclusive results may be that such procedures do not measure responses to meaningful events. The experimental methods used to explore putative changes in diffuse activation have, with few exceptions (e.g. Schooler & Zahn, 1968; Tarrier *et al*, 1979), employed responses to standardised sensory stimuli as indices of physiological activation.

The present investigation had two linked objectives. The first was to compare autonomic activity under circumstances which imposed relatively sustained demands on the subject with responses to standard laboratory procedures. The second objective was to test the hypothesis that social activity in people with schizophrenic disorder is associated with abnormal autonomic responses (Wing & Venables, 1962; Venables, 1968), reflecting either excessive activation or inhibition. In order to rate some social abilities and impose sufficient social stress over a short period, we asked subjects to mime in front of an audience of two people.

We were particularly interested in physiological responses to social interaction and stress, because social dysfunction is important as a component of both schizophrenic deficit states and premorbid rating scales. In addition, social incapacity has been cited as an index of poor outcome (Kokes *et al*, 1977; Johnstone *et al*, 1979). The evidence suggesting that important life events and critical expressed emotion in the families of schizophrenic subjects affect the

course of the disorder has strengthened the impression that sustained social stress is an important determinant of relapse.

Asymmetry of autonomic patterning in schizophrenia has assumed prominence in recent years (Gruzelier & Venables, 1974; Gruzelier & Manchanda, 1982). In developing our equipment, the opportunity was taken to record skin conductance (SC) from both sides.

Method

Patients were identified initially by hospital diagnosis and the notes were reviewed. Selection was according to Feighner criteria for schizophrenia (Feighner *et al*, 1972), but all except one of the patients appeared to have had CATEGO features of core schizophrenic disorder (Wing *et al*, 1974) at some time in their clinical career and all had had positive schizophrenic features within the previous 6 months. Twelve were in-patients. Control subjects were selected from members of the public who responded to advertisements for participants and were matched for age. Those with a history of psychological disorder in the previous 10 years or cerebral trauma, or who were taking medication of any kind which might affect the results were excluded. All subjects were paid for participating.

Each subject attended one session. After being introduced to the experiments and being given an explanation of the procedures and equipment, subjects were asked if they agreed to take part. None refused at this stage, although some patients had refused when approached on the ward. The miniature telemetry equipment and electrodes were then attached, every effort being made to keep the subject relaxed. The subject then sat alone in a comfortable chair in a dimly lit, quiet room for the first part of the session which lasted about 60 min. Communication with the experimenter took place via a microphone and loudspeaker to the side of the chair. Another loudspeaker was placed behind and 90 cm above the subject's head for the presentation of tones. A 35-cm colour television was placed to the subject's left and used to display reminders of what the tasks involved. A new message was displayed for each task. All subjects were tested for visual and auditory acuity before taking part.

Bilateral palmar SC measurements were made throughout the session using miniature telemetric equipment with a a resolution of approximately 0.001 μS and a SC range between 50 and 0.04 μS (White & Charles, 1983). One radio transmitting unit was attached to each forearm. Silver–silver chloride electrodes, 9 mm in diameter, were attached to the thenar and hypothenar eminence of each hand using collodion to form a seal around the edge of the electrode. Beckman electrode gel was injected into the electrode chambers. Although this gel is not isotonic, we found that agar-agar gel dehydrated over a period of 2 to 3 h, was unevenly distributed and had other potential disadvantages (Venables & Christie, 1980). Careful comparison of results with Beckman gel or 0.05-M NaCl agar-agar using the present equipment (data available) indicated that the only significant effects of the hypertonic solution were to elevate SC level and to prevent a slow downward drift in SC level over time. Since the aim of the present investigation was to compare groups of subjects, the absolute SC levels are not of critical importance.

SC level was sampled by computer at a rate of 10 Hz. ECG signals from electrodes placed over the subject's sternum were also monitored telemetrically. Heart rate was measured using a QRS peak detector interfaced to the computer system. The physiological data were displayed on a high resolution graphics screen during collection and recorded continuously on floppy disk with time markers every 10 s. A system with two linked computers recorded the physiological data in order to provide continuous collection and storage. A third computer was employed to control psychological procedures whose timing was also stored. A sound recording was made of each session with a time marker recorded on one track of the stereo tape. This permitted the sound replay to be synchronised with the display of SC data during analysis. The microphone was sensitive enough to detect deeper breaths and larger movements of the limbs and trunk. Room temperature was maintained at a comfortable level above 20°C.

The relatively formal psychological procedures occupied approximately 50 min and consisted of: simple reaction time, 5 min sitting quietly, 8 min sitting with a sequence of 10 auditory stimuli, the determination of critical flicker frequency, two flash threshold and set index, a sustained attention test, and a second period of rest with 6 tones. Only physiological results will be reported here.

Before either tone sequence, the subject was told that he should sit quietly for about 10 min, and that he should relax as much as possible without falling asleep. He was also informed that during the later stages of this period there would be occasional tones over the loudspeaker but that they should be ignored as far as possible. A message on the television screen also instructed the subject to ignore any noises. Each 70-dB, 1000-Hz tone was of rapid onset and offset, with rise and fall time of <2 ms and a duration of 500 ms. Tones were spaced at pseudorandom intervals between 30 and 50 s with a mean inter-stimulus interval of 40 s. The sequence of intervals was the same for all subjects.

The later part of the session was designed to provide a series of increasingly stressful social interactions, although a friendly and uncritical atmosphere was maintained throughout. After the third tone of the second series of tones, an experimenter entered the room quietly without looking at the subject and sat in a chair. At the end of the sequence of tones several minutes later, the experimenter introduced himself and said that he would like to ask some questions about how the subject got on with the tests, but before that he had to go out for a moment. He returned after 1 min with a board and a pen and sat down again in the chair, and discussed how the subject had got on in the tests in a semi-structured interview. The subject then read aloud a children's standard comprehension task and answered four questions. After a slight pause, the experimenter said: "The last thing we would like you to do is to pretend to carry out some simple daily activities without using words. Before we do that I am going to fetch somebody else." He went out of the room, waited 30 s and returned with a second experimenter. The light was then

turned on, the subject was asked to stand up and the television screen was turned towards him so that experimenters could not see the display.

The subject was then instructed that he would see the topics of his mimes on the television screen and that he should act them without speaking. When he understood what he had to do, there was a delay of about 1 min. The subject then carried out three mimes whose titles have been chosen as relatively easy to perform but susceptible to several interpretations. The first two titles were selected from a list of eight possible activities from daily life such as slicing bread or washing up. The third mime was one of four affects, either anger, fear, sadness or disgust. During the mime performances, the experimenters pretended not to identify the topics so that subjects performed the mime for up to 60 s.

In the analysis of the data, SC responses to the series of 70-dB tones were assessed visually by two experimenters and accepted if they had an onset between 1 and 3 from onset of the stimulus. Peak latency, amplitude and half decay time were calculated for each peak. Thirteen sections of the experimental session, each of 30 s duration, were selected for analysis with the start times in Table I. Before analysis, all physiological recordings were inspected by eye using a high resolution graphics display of both SC channels and heart rate. Within each of the 13 sections, the following SC parameters were calculated: mean SC level for left and right hands in μS and log μS, standard deviation for mean levels in left and right hands, the sum of the deflections in positive or negative direction during the section in each hand (trend), the mean difference in SC level between the two channels, positive and negative peak deflections of more than 2% deviation from baseline (peak count), mean peak amplitude on each side, and cross divergence between the two channels.

TABLE I

Timing of 30 second sections selected for analysis with times from start of first procedure in brackets

(1) 4 min after start of sitting quietly. (8 min)
(2) 2 min before end of tone sequence. (15 min)
(3) 35 s before experimenter's first entry. (60 min)
(4) 5 s after experimenter's entry.
(5) 30 s after start of discussing session.
(6) 10 s after start of reading aloud.
(7) 5 s after start of comprehension questions.
(8) Seated after mime procedure mentioned.
(9) Preparation for miming. After standing. (66 min)
(10) Explaining mime procedures. (30 s after section 9).
(11, 12, 13) 10 s after start of mime 1, 2, 3. (70 min)

The cross divergence measure was developed in order to estimate detailed differences in patterning of SC activity between the two sides. It was calculated by taking the difference between each successive pair of 10-Hz data points in each hand, dividing that difference by the SC level of the first value of the pair, and calculating the mean of the absolute difference between the derived left and right side values for the 299 samples. Lack of divergence is represented by zero: larger values represent increasing divergence.

The heart rate data were in the form of inter-beat intervals in milliseconds and these required conversion to beats per minute (60 000/ms count). Mean beat frequency and standard deviation were calculated for each section. Occasional signal loss or highly deviant responses which might have been due to defects in signal transmission were eliminated after visual assessment on the high resolution graphics display.

TABLE II

Details of subjects in the schizophrenic group

Age	*Duration of history (years)*	*Medication (total daily dose for oral medication)*
21	5	Oral flupenthixol 9 mg, chlorpromazine 300 mg
23	3	Depot fluphenazine 25 mg weekly, haloperidol 60 mg
27	3	Depot fluphenazine 100 mg fortnightly, trifluoperazine 30 mg, orphenadrine 150 mg
28	4	Depot fluphenazine 25 mg weekly, haloperidol 120 mg, chlorpromazine 100 mg
31	14	Depot haloperidol 150 mg every 4 weeks, trifluoperazine 30 mg, chlorpromazine 100 mg, procyclidine 5 mg *t.d.s.*
32	6	Depot flupenthixol 100 mg fortnightly, haloperidol 40 mg
33	6	Depot fluphenazine 120 mg 3 weekly, haloperidol 90 mg
36	14	Depot fluphenazine 50 mg fortnightly, chlorpromazine 100 mg, procyclidine 15 mg
39	4	Pericyazine 30 mg, chlorpromazine 225 mg, orphenadrine 50 mg *t.d.s.*
42	13	Clopixol 400 mg, fortnightly, procyclidine 15 mg, temazepam 20 mg *nocte*
54	20	Depot fluphenazine 25 mg weekly, haloperidol 60 mg, chlorpromazine 60 mg
56	31	Depot fluphenazine 50 mg weekly, trifluoperazine 15 mg, chlorpromazine 300 mg
57	30	Trifluoperazine 30 mg, diazepam 15 mg
61	19	Depot fluphenazine 100 mg fortnightly, chlorpromazine 100 mg, trifluoperazine 30 mg

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Histograms of multiple samples from all the variables were assessed by eye for normality of distribution and, if there was doubt about the distribution, they were subjected to analysis for goodness of fit to normality using the χ^2 statistic.

The levels of statistical analysis for the electrodermal variables and heart rate included: differences between groups for mean values across the 13 samples and across the two basal and later social sequence (sections 3–13), analysis of trends across 13 samples, and sequential sample by sample analysis for differences under the varying experimental conditions. One- or two-way analysis of variance, with repeated measures analysis when appropriate, was employed.

The mean, s.e.m. and range of age in the two groups were similar (control group: 40.5 ± 3.93 years, range 25–61; schizophrenic group: 37.7 ± 3.57 years, range 21–61) and all subjects were right-handed. Eight members of the control group and all members of the schizophrenic group were male. Some clinical characteristics of the schizophrenic group subjects are given in Table II.

Results

Of the subjects in the schizophrenic group, electrodermal responses to the tones in the initial tone sequence occurred on one occasion in each of three subjects (after tones 1, 3 and 9 respectively) but otherwise no responses to tones were seen. In the control group, clear electrodermal responses were seen in 11 out of 12 subjects, one of whose responses failed to habituate by the tenth tone, and a steady decline in SC response amplitude was observed in responding subjects. Responses were also absent in all subjects in the schizophrenic group during the later tone sequence when only five of the control group had electrodermal responses to the tones.

Group mean results for electrodermal variables and heart rate across the 13 sections are shown in Table III. No major differences between the groups were found among the electrodermal variables, but trends towards increased coefficient of variability and cross divergence (higher values) were seen in the right hand of the schizophrenic group when compared with the control group.

TABLE IV

Two-way repeated measures analysis of variance (group × hand) of lateralised electrodermal variables across the basal two sections (d.f. = 1, 1) and the 11 sections in the social sequence (d.f. = 1, 10)

	Groups		*Hands*		*Interaction*	
	F	*P*	*F*	*P*	*F*	*P*
Basal sections						
SC level	6.73	0.24	75.78	0.07	29.75	0.01
SC CV	133.33	0.05	0.24	0.70	0.16	0.75
Peak frequency	39.70	0.10	967.86	0.02	8.99	0.21
Peak amplitude	2.91	0.34	0.20	0.73	2.37	0.37
Social sequence						
SC level	21.81	0.00	533.43	0.00	54.08	0.00
SC CV	54.76	0.00	10.09	0.01	17.8	0.00
Peak frequency	0.51	0.50	0.38	0.56	1.02	0.34
Peak amplitude	5.12	0.98	29.23	0.00	4.57	0.06

The results of two-way repeated measures analysis of variance for the lateralised electrodermal variables across the two basal sections and across the later sequence are shown in Table IV. In the basal sections there was

TABLE III

Grand mean results for electrodermal parameters and heart rate across 13 sections, analysed using one-way analysis of variance

	Control group n = 12		*Schizophrenic group n = 14*			
	mean	*s.e.m.*	*mean*	*s.e.m.*	*F*	*P*
SC[1] level left (μS)	3.95	0.36	3.95	0.35	0.00	0.97
SC level right (μS)	4.19	0.43	5.06	0.68	1.12	0.30
SC CV left	0.03	0.004	0.03	0.005	0.93	0.65
SC CV right	0.03	0.003	0.04	0.006	3.09	0.09
Difference between sides in SC level (R − L, μS)	0.25	0.34	1.11	0.52	0.00	0.98
Peak frequency left[2]	3.56	0.57	3.54	0.24	0.03	0.85
Peak frequency right	3.41	0.64	3.59	0.78	0.53	0.52
Peak amplitude left (μS)	0.18	0.03	0.15	0.02	0.53	0.52
Peak amplitude right (μS)	0.22	0.04	0.27	0.05	1.90	0.17
Cross divergence (nS)	0.68	0.09	1.00	0.16	2.90	0.10
Heart rate (beats/min)	74.77	2.56	92.05	3.37	14.5	0.00

1. SC = skin conductance; CV = coefficient of variation (s.d./mean).
2. Peak frequency in counts/30 s with a 2% deflection from baseline criterion.

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(a) a significant interaction between groups and hands in skin conductance level, reflecting a higher mean right-hand value in both groups,
(b) a weakly significant effect for groups in coefficient of variation due to a greater variability in the schizophrenic group,
(c) a significant hands effect for peak amplitude due to increased peak amplitude in the right hand of both groups.

The difference between groups in peak frequency in the basal sections reached a 0.1 level of probability.

In the analysis of the later, social sequence (sections 3–13), strong effects for groups, hands and their interaction were found for skin conductance level and variability, reflecting the marked elevation of skin conductance level and variability in the right hand of the schizophrenic group. Peak frequency was not increased in either group or hand. An increase in peak amplitude on the right side in both groups was reflected in the significant effect for peak amplitude for hands, with a trend to a group × hands interaction.

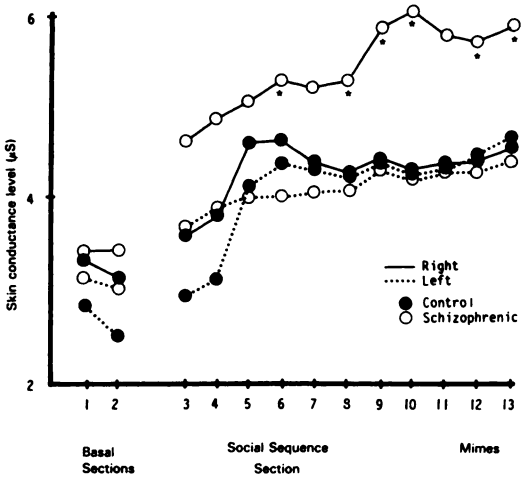

FIG. 1 Group mean skin conductance levels in 13 sections in control and schizophrenic groups. Significant difference between hands in schizophrenic group: $*P<0.05$, using repeated measures analysis of variance.

Within groups, analysis of changes in the electrodermal variables across the 13 sections using one-way repeated measures analysis of variance yielded significant changes ($P<0.02$) in the control group for all variables except peak amplitude. The results were similar in the schizophrenic group except that no significant effect was seen for peak frequency or coefficient of electrodermal variability.

Evaluation of section by section changes in SC level in either hand using one-way repeated measures analysis of variance (Fig. 1, Table V) indicated that in the later sequence (sections 3–13) significant mean increases in both hands occurred in the control group after the experimenter came into the room (between sections 3 and 4) and when starting to discuss the session (between sections 4 and 5), matched by similar but weaker trends in the schizophrenic group.

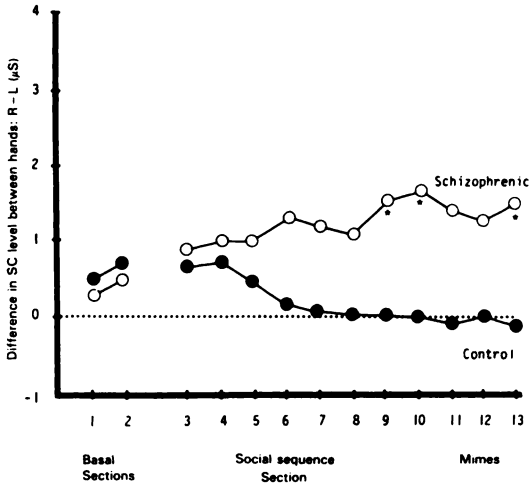

FIG. 2 Group mean differences in skin conductance level between hands in control and schizophrenic groups. Right hand minus left. Significant difference between groups using one-way analysis of variance: $*P<0.05$.

A large increase in SC level in both hands was observed in the schizophrenic but not the control group when standing in anticipation of miming (between sections 9 and 10), while small but similar increases were seen in both groups between the second mime (of a daily activity) and the mime of an emotional state (between sections 12 and 13).

Section-by-section analysis of the change in difference in SC level between hands using repeated measures analysis of variance indicated no statistically significant effects in the control group but significant increases in the schizophrenic group in right-hand level over left when starting to read aloud (between sections 5 and 6: $F[1, 13] = 6.10$, $P=0.03$) and after standing up in anticipation of miming (between sections 8 and 9: $F[1, 13] = 17.56$, $P=0.001$). Figure 2 shows the tendency to equalisation of SC level in the two hands in the control group in later sections with a divergence between the hands in the schizophrenic group, reflected in a difference ($P<0.05$) in SC level between hands in the schizophrenic group in several of the later sections (Fig. 1). Between sections 3 (before the experimenter's entry) and 7 (comprehension questions), an electrodermal left shift was seen in nine members of the control group and a right shift was found in ten members

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TABLE V
Significant ($P<0.05$) group mean changes in skin conductance level (μS) between sections

	Left hand				*Right hand*			
Sections	*Mean*	*s.e.m.*	*F*	*P*	*Mean*	*s.e.m.*	*F*	*P*
Control group								
Experimeter enters (4–3)	0.19	0.04	19.43	0.001	0.22	0.08	7.96	0.010
Discussion (7 – 6)	1.02	0.30	11.54	0.006	0.77	0.22	12.27	0.002
Mime 3 (13 – 12)	0.25	0.11	5.15	0.042	0.16	0.07	5.63	0.025
Schizophrenic group								
Experimenter enters (4 – 3)	0.17	0.12	2.00	0.179	0.27	0.13	4.34	0.055
Discussion (7 – 6)	0.12	0.07	3.31	0.089	0.18	0.08	5.02	0.041
Pre-mime (9 – 8)	0.25	0.04	38.09	0.000	0.56	0.08	46.07	0.000
Mime 3 (13 – 12)	0.11	0.05	5.38	0.036	0.22	0.10	4.99	0.042

of the schizophrenic group, the others showing small changes in the opposite direction.

Mean cross divergence was increased in the two basal sections in the schizophrenic group (control group 0.253 ± 0.049 nS per sample, schizophrenic group 0.651 ± 0.172 nS per sample: F [1, 24] = 4.36, $P = 0.05$), but a trend in the same direction was weaker in the social sequence (control group 0.750 ± 0.098 nS per sample, schizophrenic group 1.076 ± 0.165 nS per sample: F [1, 24] = 2.75, $P = 0.11$]. There was no significant difference in any of the electrodermal measures between the small group of women and the men in the control group.

The mean heart rate of the schizophrenic group was significantly higher ($P < 0.01$) than that in the control group in all sections, but the amount of change in heart rate under varying circumstances did not differ between the two groups.

Discussion

Since we were breaking new ground by using radio telemetry for measurement of SC in a group of people, it was necessary to establish the reliability of the system. In general, reliable and sensitive measurement of SC and heart rate under ambulant conditions proved possible. Subjects quickly became used to wearing the small transmitter units.

Our aims in extending the range of techniques of psychophysiological measurement in this way were to compare the autonomic responses of a schizophrenic group in a social setting with responses to standardised low intensity tones, and to examine the possibility that people with chronic schizophrenic disorder might show excessive excitatory or inhibitory responses to social stress. The virtual absence of responses to tones in the schizophrenic group, other than in one subject who could be classified as a fast habituator (Patterson & Venables, 1978), was unexpected but provided the opportunity to assess other autonomic response characteristics of a 'non-responder' group.

There was no evidence to suggest that non-responsivity to low intensity tones in our sample was associated with reduced SC responsivity or variability in the schizophrenic group while sitting at rest or during the socially active sections approximately 1 h after the start of recording. Indeed, a number of findings indicated greater physiological activity than in the control group: a bilateral increase in SC variability associated with a trend to increased peak frequency when sitting early in the session, a trend towards bilaterally increased SC variability in some of the socially demanding sections even after compensation for differences in SC level, an overall increase in SC level and peak amplitudes on the right side in the later sections, and increased heart rate throughout.

Shorter-term autonomic responsivity in later sections in both groups varied with circumstances but was not generally increased or reduced in the schizophrenic group. The major exception was the electrodermal response which took place during the preparation for miming. This is difficult to evaluate because in the schizophrenic group electrodermal activity, particularly on the right side, changed when the subjects stood up. No comparable alteration was

evident in the control group, and changes in heart rate in the groups were similar and at least partly attributable to alteration in posture. As SC level on the right in the schizophrenic group continued to rise in section 10 whilst miming was further explained, it seems probable that the changes from section 8 to 10 were mainly psychological in origin, but a greater separation of standing up and preparation for miming would have been preferable. Our pilot studies with healthy volunteers and hospital patients had led us not to expect effects on electrodermal activity due to standing up.

Contrary to our prediction, the sections when subjects mimed repeatedly in front of two experimenters were not accompanied by bilateral evidence of abnormal autonomic responses in the schizophrenic group when compared with controls. This might have reflected lack of social engagement, but participation and mime ability were not impaired in the schizophrenic group (White *et al*, 1987). Since the bulk of experimental evidence suggests that unmedicated subjects with schizophrenic disorder show raised SC levels (Lader, 1975; Gruzelier & Hammond, 1978; Bernstein *et al*, 1981), it is probable that SC level was reduced in our sample by neuroleptic treatment. Even so, the prediction of augmented responsiveness to social stress was partially correct since electrodermal activity was increased on the right side.

The most striking findings were the persistently increased heart rate and the electrodermal laterality effect. Elevated heart rate in schizophrenic groups is perhaps the most consistent finding in the literature (Depue & Fowles, 1973; Lader, 1975; Zahn *et al*, 1981) and may in part be ascribed to medication.

The electrodermal laterality effect was seen most clearly when the shifts in SC level between the start and end of the social section in the two groups were compared (Fig. 2). The effect began during questioning about the tests and reading aloud, while the subject was still seated, and was enhanced during the miming section.

The lateralised difference in SC level between the groups is consistent with previous reports (Gruzelier, 1973; Gruzelier & Manchanda, 1982), in which enhanced autonomic responsiveness to tones on the right in people with schizophrenic disorder has been the most frequent finding. Such right-sided enhancement of responses to tones was recently found by Gruzelier & Manchanda (1982) to be associated with 'negative' or Bleulerian symptoms. Bernstein *et al* (1981) reported that larger right-hand responses to tones were associated with increased EEG alpha blockade in the left hemisphere, indicating a physiological hemispheric activation effect, but that this link was not specific to a schizophrenic diagnosis. Gruzelier & Venables (1974) have also reported a sustained right-hand shift in electrodermal level during a psychological task with an increase in right-hand excess as SC levels increased. Other reports of sustained situational measures (e.g. Tarrier *et al*, 1979; Sturgeon *et al*, 1981) have recorded SC activity from one hand only, usually the left hand, and have not assessed lateral asymmetry.

The interpretation of the electrodermal laterality effects depends in part on evidence concerning anatomical lateralisation of central nervous control of electrodermal activity. Suggestions that limbic structures in the temporal lobe could mediate lateralised autonomic effects remain unsupported by relevant evidence in animals or man (see review by Toone *et al*, 1981), but the recent demonstration of left-sided elevation of dopamine concentrations in the amygdala of post mortem brains from schizophrenic subjects (Reynolds, 1983) might reflect relevant limbic changes.

Lateralisation of influences from other sites must also be considered. Manipulation of the cerebral cortex in cats, either in the 'limbic' area on the medial surface of a cerebral hemisphere (Isamat, 1961) or in the premotor area 6 (Schwarz, 1937), can produce preferential alterations in electrodermal activity on the contralateral side. In man, Gruzelier & Manchanda (1982) cited neurosurgical evidence in favour of contralateral electrodermal modulation from fronto-temporal sites. Furthermore, early reports clearly suggested contralateral influences on sweating from the frontal, premotor cortex (Kennard *et al*, 1934; Kennard, 1935; Netsky & Starr, 1948). Despite the general lack of consistency in findings of asymmetrical SC activity (Freixa i Baque *et al*, 1984), it would appear inappropriate to exclude an anatomical basis for contralateral SC control at a cerebral level.

If contralateral control of electrodermal does occur, then our data would support suggestions of abnormal cerebral activity in the dominant hemisphere in people with schizophrenic disorder.

In interpreting the non-responsiveness to tones in our schizophrenic group, several factors require consideration. The bulk of reports indicate that non-responsivity to low intensity tones correlates with generally reduced autonomic activity (Gruzelier & Venables, 1972; Gruzelier, 1976; Straube, 1979). Since our data are inconsistent with those reports and since we had no responding schizophrenic group for comparison, conclusions from our results can only be tentative. We have no reason to suspect that methodological factors affected responding to tones. In other work, non-responsivity to low intensity

tones has not been accompanied by reduced responsivity under other standardised stimulus conditions (Gruzelier *et al*, 1981), or by altered EEG changes after tone stimuli (Bernstein *et al*, 1981). Gruzelier & Manchanda (1982) recently commented that responsivity to tones reflects factors which are relatively specific to the tone response procedure, while sustained changes in SC level are more likely to reflect arousal.

Another pertinent issue is that of the physiological need for increased pseudomotor activity on hands under some circumstances. Some of the determinants of SC responses appear to be emotional, and others more cognitive or anticipatory of motor function (Germana, 1969; Bernstein, 1979; Maltzman, 1979; O'Gorman, 1979; Lang *et al*, 1980). There does appear to be agreement in the literature that electrodermal responses to intermittent abrupt events, such as tone stimuli, depend on sensory input analysers which are largely unconscious and, at least at times, cognitively sophisticated. Therefore, such responses may be sensitive to cognitive disruption as well as to putative general changes in activation, and so theoretically unsuitable as a measure of arousal in people susceptible to schizophrehnic disorganisation. The reports by Straube (1979) and Bernstein *et al* (1981), suggesting that non-responding to tones was associated with increased cognitive disorganisation in a schizophrenic group, are compatible with this hypothesis.

With regard to the effect of medication, although it remains possible that a bimodal distribution of responding is somehow revealed by medication, sustained treatment with neuroleptics appears not to modify transient responses to low intensity auditory stimuli and previous results have in general not supported a pharmacological interpretation of electrodermal non-responding (Venables, 1977; Straube, 1979; Bernstein *et al*, 1981).

The incongruity between normal or increased levels of electrodermal activity and increased heart rate and non-responsiveness to tones in our schizophrenic group may be explained by inadequacy of the tone response procedure as an index of arousal in schizophrenia. Sustained differences between the groups under socially active conditions, as used in the present investigation, appear to be appropriate and practicable indices of a possible underlying dimension of arousal and may indicate the time course of excessive psychophysiological responses, despite the relatively poor standardisation of experimental conditions when compared with tone presentation procedures.

The hypothesis that social dysfunction is a result of excessive activation is supported at least partially by our results. If SC activity is controlled from the contralateral side of the brain, the data may support the hypothesis of dysfunction in the dominant hemisphere in at least some patients with persistent schizophrenic disorder, but further information is required to substantiate such a suggestion.

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