What does electrodermal activity tell us about prognosis in the schizophrenia spectrum?

Michael E. Dawson a,*, Anne M. Schell b

a Department of Psychology, University of Southern California, Los Angeles, CA 90089-1061, USA
b Department of Psychology, Occidental College, Los Angeles, CA, USA

Received 1 October 2001; accepted 4 October 2001

Abstract

Various dysfunctions in electrodermal activity (EDA) have been found in schizophrenic patients. The present paper reviews evidence that the electrodermal dysfunctions may carry prognostic information regarding subsequent symptoms, as well as social and occupational outcome. Although the findings are not entirely consistent, heightened electrodermal activity as indicated by frequent orienting responses to innocuous stimuli, elevated skin conductance level (SCL), and frequent non-specific skin conductance responses (NS-SCR) is most often associated with poor symptomatic, social, and occupational outcome in schizophrenic patients. There have been no studies that have directly examined electrodermal prognostic indicators in schizotypal individuals. However, high-risk studies suggest that heightened electrodermal activity may be prognostic of poor outcome in schizotypals as well. Thus, abnormally high electrodermal arousal and reactivity is predictive of poor outcome in at least some patients. The theoretical implications of these findings and directions for further research are briefly discussed.

Keywords: Schizotypy; Orienting; Arousal; Prognosis; Schizophrenia; Electrodermal activity

Electrodermal activity (EDA) has been used for over a century as a non-verbal measure of cognitive and emotional processes in general psychophysiology and for nearly that long in the study of schizophrenia (Peterson and Jung, 1907). The modern era of studying EDA can be dated from the work of Venables and others in the 1970s (Lykken and Venables, 1971; Venables and Christie, 1973). Peter Venables was a premier leader in defining the modern instrumentation, quantification techniques, and terminology that have become standard in electrodermal recording.

Unfortunately, as with much of the literature dealing with schizophrenia, EDA findings in schizophrenia often lacked consistency. However, in the 1980s there emerged a general consensus that there existed two independent EDA abnormalities in schizophrenia (see reviews by Spohn and Patterson, 1979; Öhman, 1981; Bernstein et al., 1982; Dawson and Nuechterlein, 1984; Holzman, 1987). Again, Venables was one of the principal leaders in defining these two types of abnormality, this time in collaboration with Gruzelier (Gruzelier and Venables, 1972).
The two types of EDA abnormalities are depicted in Fig. 1. The middle trace depicts normal EDA during a short rest phase and a brief series of three innocuous tones. The normal middle trace shows moderate skin conductance level (SCL), an occasional non-specific skin conductance response (NS-SCR) in the absence of any external stimuli, and a skin conductance orienting response (SCOR) immediately following onset of the first two tones (indicated by arrows), which then completely habituates. The bottom trace depicts the first type of EDA abnormality in schizophrenia characterized by somewhat lower SCL, fewer NS-SCRs, and in particular few if any SCORs to the tones. The upper trace depicts the second type of EDA abnormality, characterized by high SCL, excessive NS-SCRs, and the presence of SCORs that may be slow to habituate.

The implicit promise of the presence of the two measurable EDA abnormalities is that they may identify clinically meaningful differences in subgroups of schizophrenia. The focus of the present article is on the possible prognostic value of EDA measures in discriminating good and poor outcome subgroups. We first review EDA predictors of symptomatic and of social and work outcome in schizophrenia; second, we discuss the possible relevance of the schizophrenia prognostic findings to schizotypy; and third, we identify some theoretical implications and potentially important new directions for future research.

1. EDA and schizophrenia

Although a variety of paradigms have been employed, the principal procedures used to study EDA abnormalities in schizophrenia involve a simple rest phase followed by an orienting response paradigm such as that depicted in Fig. 1. The typical EDA dependent variables include (1) responsivity to the tones (e.g., the number of SCORs elicited by the tones and the number of trials to habituation) and (2) general arousal (e.g., the number of NS-SCRs and the SCL). For a review of methods of recording and quantifying EDA, see Dawson et al. (2000).

1.1. Prediction of symptoms

Several studies have reported that heightened electrodermal responsivity and arousal are predictive of poor later short-term symptomatic outcome (Frith et al., 1979; Zahn et al., 1981; Straube et al., 1989; Dawson, et al., 1992; Straube, 1993). The typical design employed in these studies involved recording EDA from patients hospitalized during the acute phase of the schizophrenic illness, while symptomatic outcome was measured several weeks or months later. The typical results of these studies are that heightened EDA (e.g., more SCORs and NS-SCRs) was significantly correlated with poor short-term symptomatic recovery during the subsequent outcome test. Brekke et al. (1995) reported a similar finding when studying symptomatic outpatients; heightened EDA was associated with more disorganized symptoms at the time of the electrodermal test and predicted more disorganized symptoms at a 6-month follow-up. However, it is important to note that the poor outcome subgroups in most of the studies did not differ symptomatically from the good outcome subgroups at the time of the EDA test, indicating that EDA hyper-arousal was predictive of outcome independent of symptomatic severity at the time of testing. All in all, the results suggest that heightened EDA reflects processes present during the symptomatic period that are related to poor recovery from schizophrenia symptoms.

EDA has also been recorded from patients during social interactions with their relatives in contrast to a simple orienting paradigm. Sturgeon et al. (1984) found that high rates of NS-SCRs while interacting with relatives were associated with relapse over a 9-
month follow-up. Similarly, Tarrier and Barrowclough (1989) found that patients who relapsed over a 2-year period had higher EDA in the presence of their relatives than those who remained well. Interestingly, this relationship between EDA and relapse was found only when EDA was measured during the index hospitalization and not during remission. These results suggest that poor arousal modulation, particularly while symptomatic, hinders recuperative processes.

Consistent with the observation that the relationship to prognosis may differ for EDA measured during active psychosis versus remission, the nature of EDA abnormalities in schizophrenia is at least partly determined by the symptomatic state of the patient. Dawson et al. (1994), for example, reported that tonic EDA arousal (SCL and NS-SCRs) was abnormally elevated during a psychotic period but not during clinical remission. Moreover, heightened EDA has also been found in the weeks prior to psychotic relapse or exacerbation (Hazlett et al., 1997). These findings are consistent with the view that EDA hyper-arousal is a mediating vulnerability indicator, one that changes with symptomatic changes and perhaps in anticipation of symptomatic changes, rather than a stable vulnerability indicator (Dawson and Nuechterlein, 1984). Thus, careful notation of the clinical state of the patient during EDA testing is important in order to detect and interpret EDA abnormalities.

Although EDA can change with changes in symptomatic state, it is still possible for it to serve as a prognostic sign. For example, abnormally high EDA arousal during times of emotional upheaval (e.g., during a symptomatic state or a pre-psychotic period) may be prognostic of poor outcome. Alternatively, being in the high end of the normal range of EDA arousal during remission may possibly be prognostic of poor outcome. The relevance of the state of the patient at the time of EDA testing for determining its prognostic value is an important issue for future research.

In sum, heightened EDA arousal and reactivity has been associated with the presence of positive psychotic symptoms (Dawson et al., 1994), the impending return of psychotic symptoms in remitted schizophrenic patients (Hazlett et al., 1997), poor short-term recovery from psychotic symptoms (Frith et al., 1979; Zahn et al., 1981; Straube et al., 1989; Dawson et al., 1992; Brekke et al., 1995), and poor long-term poor prognosis (Tarrier and Barrowclough, 1989). However, seemingly divergent results also have been reported. One follow-up study of schizophrenic patients who were tested at the end of their hospitalization, when their positive symptoms had presumably abated, showed that patients who relapsed within 1 year tended to be electrodermally hypo-responsive during performance of a continuous performance test (Mussgay et al., 1993). These findings, which appear inconsistent with those reviewed earlier, may be due to the remitted state of the patients at the time of the EDA test, or the use of a cognitive task rather than a simple orienting task. However, lower EDA reactivity in an orienting task without high cognitive demands has also been reported to predict longer hospital stays and the shorter times to relapse in a Swedish cohort of acutely symptomatic schizophrenic patients (Hultman et al., 1996).

All in all, the majority of findings indicate that heightened EDA during symptomatic states is associated with poor symptomatic prognosis, but significant minority findings show contrary relationships.

1.2. Prediction of social and work outcome

The area of social and occupational functioning in schizophrenia represents an outcome domain only moderately correlated with symptomatic outcome (Strauss and Carpenter, 1972). As in the case of symptomatic prognosis, studies using EDA variables to predict social and work outcome have reported inconsistent results. Rissling et al. (2000) obtained EDA data during a rest phase and an orienting paradigm from young, predominantly male recent onset patients at a symptomatically stabilized outpatient point a few months following initial hospitalization. At a 1-year follow-up test, the patients were divided into good and poor outcome groups. Good social and work outcome required that the patient interact with friends at least once a month and be able to support him/herself through at least part-time work. Patients with a poor outcome exhibited higher tonic EDA (SCL, NS-SCRs) at the outpatient stabilization test than did good outcome patients, and they were more likely to be SCOR responders, whereas good outcome patients were more likely to be SCOR non-responders.

Other mixed results also have been reported. Öhman et al. (1989), for example, used a standard orienting paradigm with a sample of male patients,
and found that SCOR non-responding was associated with poor social outcome at a 2-year follow-up assessment. However, Wieselgren et al. (1994) reported the reverse relationship in a subgroup of female patients, finding that high levels of EDA were predictive of poor outcome.

Thus, as with predictions of symptomatic outcome, predictions of social and occupational outcome using EDA measures differ in their direction, even when very similar paradigms are used to obtain the EDA measures. Although the majority finding is that high EDA arousal is predictive of poor social and work outcome, a significant minority finding is in the opposite direction. Further research is clearly needed to determine whether these discrepancies are due to the nature of the patients studied (male versus female, recent onset versus more chronic, cultural factors), the level and type of symptoms present when EDA is assessed (acute versus remitted phase, positive versus negative symptoms), or other factors.

2. EDA and schizotypy

The issue of prognosis has generally not been studied with schizotypal individuals and no study, to our knowledge, has investigated prognosis in schizotypal individuals using EDA as the predictor variable. EDA studies of schizotypy have focused primarily on documenting the presence of EDA abnormalities in schizotypy and on determining whether EDA abnormalities differ for different types of schizotypy. For an excellent review of this heterogeneous literature, and a proposal to make sense of the literature with a three-syndrome model, see Gruzelier and Raine (1994).

2.1. Prediction of symptoms

Although EDA prognostic indicators in schizotypy have not been directly investigated, two studies bear indirectly on the issue. The first study involved a reanalysis of data from the Copenhagen schizophrenia high-risk project (Cannon et al., 1990). In this project teenage high-risk offspring of schizophrenic mothers had EDA measured in 1962 and had diagnostic evaluations made in approximately 1972. The diagnostic evaluations revealed 15 schizophrenics, seven with predominately negative symptoms and eight with predominately positive symptoms. Of the seven predominately negative-symptom schizophrenics, all seven were SCOR non-responders in 1962. Of the eight predominately positive-symptom schizophrenics, seven were SCOR hyper-responders in 1962.

Concurrent with the 1962 EDA tests, schoolteachers’ ratings were obtained. Subjects who became predominately negative-symptom schizophrenics were rated as exhibiting significantly more negative symptom-like problematic school behavior (e.g., passivity, social unresponsiveness, isolation), whereas subjects who became predominately positive-symptom schizophrenics exhibited significantly more positive symptom-like problematic school behavior (e.g., aggression, irritability, distractibility). Thus, some members of the two groups may have been diagnosable as schizotypal in 1962. If true, the SCOR data can be considered as having prognostic value for types of future schizophrenia among a group of schizotypals. The point is that the high-risk teenagers were not in a completely asymptomatic state at the time of the EDA test and that school behavioral problems and EDA abnormalities were predictive of later positive and negative schizophrenia.

The two groups of schizophrenics also differed on other variables (e.g., delivery complications were more common in the negative-symptom schizophrenics and severe family disturbance was more common in the positive-symptom schizophrenics). Thus, EDA was only one variable in a larger cluster of variables that predicted later outcome. The main point for present purposes is that EDA responsivity measured from high-risk teenagers who already were displaying abnormal premorbid school behavior (and possibly schizotypy) had prognostic predictability for two different types of schizophrenia approximately 10 years later.

In the second study relevant to the prognostic value of EDA for schizotypal individuals, Raine et al. (in press) analyzed data from the Mauritius longitudinal project to test whether EDA measured at age 3 and 11 years was related to measures of schizotypal personality at ages 17 and 23 years. The schizotypy measure at age 17 was the Schizophrenia scale developed by Venables et al. (1990), whereas the measure at age 23 was the Schizotypal Personality Questionnaire developed by Raine (1991). The electrodermal measures at ages 3 and 11 consisted of SCL and skin conductance responses to innocuous tones and loud aversive noises.
The key findings of Raine et al. (in press) were that individuals who consistently scored high on schizotypal measures at ages 17 and 23 were characterized by heightened EDA arousal and responsivity throughout childhood at ages 3 and 11. These findings support the view that heightened EDA is an early risk factor for schizotypal personality. Unfortunately, these results do not bear directly on the present issue of prognosis in the strict sense. Prognosis refers to the likely future course and outcome of a disease or disorder. The heightened EDA observed at the ages of 3 and 11 by Raine et al. (in press) was not obtained from individuals with a diagnosed disorder, and therefore cannot be considered prognostic in the sense defined above. If EDA were measured from the individuals after they showed signs of schizotypy, and was then related to later outcome, then EDA would be considered prognostic.

This discussion raises the interesting issue of the relationship between markers of vulnerability and prognosis. Vulnerability refers to some relatively enduring characteristic of an individual that significantly increases the probability of a future illness. Prognosis, on the other hand, refers to the likely course and outcome of an illness. For example, an excessively high cholesterol level in a disease-free individual is a marker of the vulnerability for future cardiovascular disease. However, an excessively high cholesterol level in an individual who has a history of cardiovascular disease carries a prognosis of likely future episodes of the disease. Most if not all variables that are vulnerability indicators also carry information about poor prognosis once the disease has onset. Thus, heightened EDA may provide both vulnerability and prognostic information for disorders in the schizophrenia spectrum.

3. Theoretical implications and directions for future research

Our review of the research relating EDA to outcome in schizophrenia indicates that the most common finding is that electrodermally hyperactive patients (higher SCL, more NS-SCRs, and more frequent SCORs as depicted in the top trace of Fig. 1) have poorer outcomes, both in respect to symptoms and to social and occupational functioning, although there are reports of poorer outcome among SCOR non-responders as well. In research possibly related to prognosis in schizotypy, higher EDA levels in high-risk populations were associated with later development of positive symptom schizophrenia and with later development of schizotypal characteristics.

It may be useful to view the relationship between EDA and outcome from the theoretical perspective of the familiar inverted-U shaped relationship between arousal and performance (Yerkes and Dodson, 1908). Beyond a minimal level necessary to initiate attentional processes and problem-solving, heightened arousal may interfere with cognitive processing, in part by restricting the range of attention (Easterbrook, 1959) and in part by reducing the ability to discriminate relevant from irrelevant information (Gjerde, 1983). We have previously suggested that patients with schizophrenia have fragile mechanisms of arousal modulation, that environmental stressors may produce hyperarousal, and that this hyperarousal interacts with social variables to contribute to the return of symptoms (Dawson et al., 1983, 1994). As arousal levels rise, hallucinations, delusional thoughts, and inappropriate associations may become more frequent and difficult to ignore. Moreover, high arousal may be perceived as unpleasant to patients and arousal itself may be difficult to ignore, leading to state-oriented rather than action-oriented coping, which further interferes with cognitive functioning (Kuhl, 1981).

We believe that there are at least three important directions for future research regarding EDA and prognosis in the schizophrenia spectrum. The first direction is to study EDA predictors of both symptomatic and social/occupational outcome among schizotypal individuals. As we pointed out earlier, this has never been done to our knowledge. This is a promising direction for future research given the encouraging findings regarding EDA predictors of schizophrenia prognosis coupled with the suggestive EDA findings related to the vulnerability for schizotypy.

EDA is often assumed to be a trait characteristic of individuals. Indeed, EDA variables do exhibit significant stability over a 1-year interval in both schizophrenic patients and normal controls (Schell et al., in press). However, other findings indicate that EDA also is significantly influenced by the state of the patients. For example, Dawson et al. (1994) reported that EDA arousal was abnormally high in a psychotic
state, but not in a remitted state. Olbrich et al. (2001) recently reported theoretically consistent findings with cardiovascular measures of arousal. The finding that EDA is sensitive to changes in state among schizophrenics suggests that the same may be true of schizotypals. If schizotypal features fluctuate over time much like schizophrenic symptoms, and if EDA is sensitive to and perhaps predictive of changes in these states, a second important direction for future research is to carefully measure and report the state of the individuals in the schizophrenic spectrum at the time of EDA testing, perhaps using longitudinal repeated-measures designs in which the state will change.

Finally, it is generally agreed that both schizophrenia and schizotypy are heterogeneous disorders. Although there is less agreement about the specific factor structure of these disorders, there are suggestions of three parallel factors in both disorders (Venables and Rector, 2000). There are also indications that EDA abnormalities may differ in the different subtypes of these disorders (e.g., Bernstein, 1987; Gruzelier and Raine, 1994). Therefore, a third important direction for future research is to distinguish typologies of schizophrenia and schizotypy when examining EDA predictors of outcome. EDA prognosticators may differ for the different subtypes of the disorders in the schizophrenia spectrum.

References


in schizophrenics after acute psychotic episodes. J. Abnorm. Psychol. 110, 142–150.


Rissling, A., Schell, A.M., Dawson, M.E., Nuechterlein, K.H., 2000. EDA measures as predictors of 1-year social and work outcome in schizophrenia. Psychophysiology 37 (Suppl. 1), S82.


