Investigation into the effects of Classical Turkish Music on galvanic skin response and skin temperature of schizophrenic patients

Saime Akdemir[1], Sadık Kara[1], Vedat Bilgiç[2]
[1]Institute of Biomedical Engineering
Fatih University, Hadimkoy
Istanbul, Turkey
saimeakdemir@st.fatih.edu.tr

[2]Bakırköy Mental and Nervous Diseases Training and Research Hospital
Istanbul, Turkey
skara@fatih.edu.tr

ABSTRACT: *This study was conducted to investigate whether two electrophysiological signals, which are galvanic skin response (GSR) and skin temperature could be altered when exposed to different auditory stimuli such as Classical Turkish Music (CTM) and acoustic white noise. We measured physiological responses of the twenty-three schizophrenic patients and twenty-three healthy subjects in rest and auditory stimulation conditions. Our results showed that patients have greater skin temperature values than controls. We found elevated skin conductivity in response to the white noise and CTM exposure in both groups. Although schizophrenic patients had greater values of skin temperature, healthy subjects exhibited greater skin conductivity in response to the white noise and CTM exposure than did patients. In conclusion, our study has shown that skin conductance responses to CTM might be used as an index of person's stress level and this type of stimuli could be called as relaxing music.*

Keywords: Biomedical instrumentation, Galvanic Skin Response Electrophysiological signa

Received: 2 March 2010, Revised 14 April 2010, Accepted 19 April 2010

1. Introduction

Schizophrenia is one of the most serious mental disorders. Patients with schizophrenia show some positive and negative symptoms including delusions, hallucinations, disorganized speech and cognitive impairment according to the diagnostic criteria of DSM-IV [1, 2]. Since the syndrome was first described in the 19th century, psychiatrists have started to investigate the schizophrenia. It is assumed that both genetic and environmental factors are related to the aetiology of schizophrenia.

1.1 Stress-vulnerability model

The desire to understand the pathophysiology of schizophrenia has inspired an explosion in research over the past decade. It is assumed that the course of schizophrenia [3] can be understood with the stress vulnerability model. According to this model, schizophrenia is caused by an underlying psychobiological vulnerability, determined early in life by genetic and early environmental effects. It is believed that among psychosocial factors that can influence schizophrenia, stress, coping skills and social sports are most important.

There are some findings about a relationship between stressful life conditions and schizophrenia. According to vulnerability stress theory [4], the appearance of an active episode of schizophrenia is determined by both people's vulnerability and the level of stress in their environment. In a study [5], stress was measured in acute schizophrenics, chronic schizophrenics, and normals by a 130-item scale constructed that covers 21 stress categories within the areas of social performance, family interaction, social interpersonal reaction, and social maladaptive activities such as substance abuse. According to this study, chronic patients reported the highest level of stress, followed by acute patients and normals had the lowest total stress scores.

1.2 Physiological reactions in emotional and stressful conditions

Past decades have witnessed the introduction of a wide variety of new methods for the study of the functioning of different systems involved in the control of emotion or anxiety in psychiatric disorders. Emotion which is known as feelings like experiences of arousal, pleasure or displeasure and the specific primary effects of anger, fear, happiness, sadness, surprise and disgust, is often associated with expressive behaviors such as smiling and with peripheral physiological responding such as heart rate changes, sweating and skin resistance changes. When anxiety responses are experimentally induced by stress, the particular indices by which such responses are to be evaluated must be specified. Galvanic skin response (GSR) measures of autonomic nervous system (ANS) activity have been frequently employed for this purpose, since ANS arousal is generally considered to be an important attribute of anxiety.

1.2.1 Galvanic Skin Response Patterns

GSR, also known as the electrodermal response which is easily measured and relatively reliable has been used as an index for providing measurable parameter to understand a person's internal state or emotional responses. GSR is a psychophysiological phenomenon exhibited by skin containing sweat glands [6]. It consists of a decrease in skin resistance or a decrease in impedance or a change in potential in response to an attention getting or alerting stimulus. Active sweat glands, which in humans are brought into action by the sympathetic nervous system, cause GSR [7]. It is believed that sweat rises in ducts, spreads laterally, hydrating the stratum corneum and reduces its resistance. Other than sweat gland activity, the epidermal membranes of the skin becoming permeable in response to neural stimuli have also been considered to decrease the skin resistance [8]. Skin conductance shows the emotional state as reflected in changes in the sympathetic nervous system. Each time this part of the sympathetic nervous system is activated, the skin conductance increases before the sweat is removed and the skin conductance decreases.

In a study [9], it is suggested that GSR might be a useful index of stimulus detection with a schizophrenic or autistic child who may not be capable of responding verbally. By comparing the GSR response of schizophrenic children with normal children, they found that the schizophrenic children failed to maintain habituation over the stimulus series and could be differentiated from normal children on the basis of a lower mean GSR response. These investigators interpreted these findings as evidence that the schizophrenic child has diminished sympathetic responsivity, which is detectable through the GSR. Psychophysiological measures are widely used to understand the functioning of internal systems of the body to an emotional stimulus. In an experiment [10], GSR was used as the physiological measure in healthy subjects in response to musical stimulus. The assumption is made here that GSR is a manifestation of emotional response. A decrease in electrical resistance is thus interpreted as being due to an increase in emotional excitation while an increase in electrical skin resistance is interpreted as being due to a decrease in emotional excitation.

1.3 Aims of the study

The goal of the present study was to explore differences between schizophrenia patients and healthy controls in the GSR and skin temperature in response to different auditory stimuli (Classical Turkish Music -CTM- and acoustic white noise). Investigation of these two ANS indexes in response to CTM was never performed in schizophrenic patients till now. The hypothesis being tested in here is that the CTM produces differential effects upon GSR and, more specifically, that this kind of music designated as exciting produces a decrease in electrical resistance of the skin.

2. Methods

The present experiment attempts to understand the difference between GSR and skin temperature values of the schizophrenic patients and the healthy controls in response to two different auditory stimuli.

2.1 Participants

In this study, a control group and an experimental group which includes normal hearing schizophrenic patients were compared using physiological signals. Twenty-three adults with a DSM-IV (American Psychiatric Association, 2000) diagnosis of schizophrenia spectrum disorders and age-matched control subjects participated in this study (Table 1). An experienced psychiatrist from Bakırköy Mental and Nervous Diseases Training and Research Hospital, which is specialized for psychiatric disorders diagnosis and treatment, diagnosed these schizophrenic patients.

	Controls	*Patients*
Participants	23	23
Male/Female	11 / 12	11 / 12
Age (years)	33.95 ± 8.33	33.39 ± 6.86
Dominant hand	*All right*	*All right*

Table 1. Clinical and demographic data of participants

The study was approved by the both university and hospital ethics committee, and a written informed consent was obtained from all subjects. Participants volunteering as the control group were excluded if they showed a history of psychotic disorder, or if any of their first-degree relatives had been diagnosed with the schizophrenia, schizophrenia spectrum or bipolar affective disorder.

2.2 Affective Stimuli

To clarify the effect of CTM and to compare its results, another type of auditory stimulus, acoustic white noise (WN), was used in this study. The WN in this study was a kind of relaxing sound of rain on a river.

It is known that CTM which is a form of music which matured and developed in the period of Ottoman State used as a therapeutic tool for specifically treating mental disorders [11]. According to Farabi, who was a great Turkish scientist, the effects of the some makams of Turkish music on the soul were classified as follows [12]: Rast makam brings someone happiness and comfort.

Rehavi makam brings someone the idea of eternity. Hüseyni makam brings someone serenity, ease. An instrumental clip with the name of "Çeçen K" that belongs to Tanburi Cemil Bey, who was a famous CTM composer, was used as a second stimulus known as an example of Hüseyni makam.

All participants sequentially listened to these stimuli binaurally through headphones with the intensity of 75 dB.

2.3 Measurement System

Skin surface temperature and GSR were recorded simultaneously with BIOPAC MP150WSW (BIOPAC Systems Inc., Santa Barbara CA) data acquisition system. BIOPAC's TSD202B temperature transducer along with the SKT100C amplifier was utilized to measure the peripheral temperature. Subjects hand surface temperature was recorded with this transducer. GSR data were collected via BIOPAC's GSR100C. The GSR100C uses a constant (0.5V) voltage technique to measure skin conductance. Ag/AgCl electrodes were filled with .05M NaCl electrode paste and affixed to the medical phalanges of the 1st and 2nd fingers of the subjects's non-dominant hand with Velcro straps as it is shown in Figure 1. GSR and temperature signals were sampled at 250 Hz.

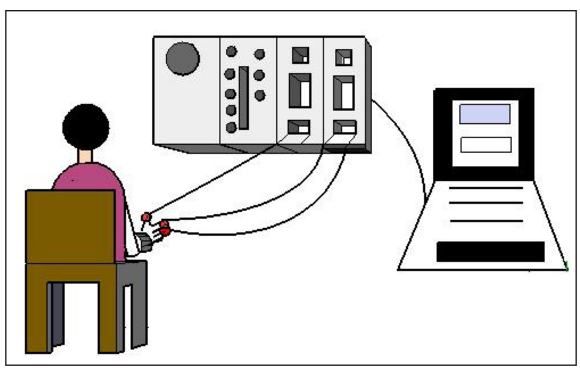

Figure 1. Illustration of the measurement system

2.3.1 Procedure

In this study, the effects of CTM and WN on GSR and temperature data on schizophrenic patients and healthy controls were investigated. The investigation took place in a quiet, illuminated and temperature controlled room. Recordings were taken continuously for about eight minutes for each participant. The subject was asked to participate to the whole procedure with eyes closed to avoid distractions.

There are some findings about 2-4 minutes are enough to measure physiological parameters against to some excitations such as fear, stress, anxious [13]. So, 2 minutes defined as acceptable duration of each period in this study. The subjects were exposed to four conditions: silence, acoustic white noise, music and silence. First two minutes, GSR and temperature data were collected without an auditory stimulus to identify baseline values for each subject. Following two minutes acoustic WN, then the next two minutes CTM (Hüseyni makam) was used as a kind of auditory stimulus. Last two-minute recordings were collected without an auditory stimulus.

2.3.2 Data Analysis

The data were analyzed using the MATLAB 7.0®. Both GSR and skin temperature recordings were examined 2-minute intervals according to the procedure. Average temperature changes and average skin conductance responses calculated in each period.

In the present study, Welch method that is based on Fast Fourier Transform which is one variety of Fourier method was preferred to analyze the skin conductance recordings. Welch method is defined as a kind of classical, non-parametric method. The spectral estimation with Welch method can be expressed as follows [14]:

$$\tilde{P}_{per}(w) = \frac{1}{MUL}\sum_{i=1}^{L}\left|\sum_{n=0}^{M-1} x_N^i(n)W(n)e^{-jwn}\right|^2, \quad \textbf{(1)}$$

where

$$x_N^i(n) = x_N\left[n+(i-1)M\right], 0 \le n \le M-1, 1 \le i \le L,$$
$$U = \frac{1}{M}\sum_{n=0}^{M-1} W^2(n), \quad \textbf{(2)}$$

where $x_N(n)$ is the signal of length N and is divided into L sections with length M overlapping each other, $x_N^i(n)$ is the number i section of $x_N(n)$; ion of length M. The value of each parameter was normalized to the range of zero to one that is observed to be the maximum power spectral density.

In this study, each section was windowed with a Hamming window and modified periodograms were computed and averaged. Hamming window of 10 samples with an overlap of 5 samples was used in the Welch method**.**

3. Results

Data were analyzed by the SPSS (v.13.0) statistical package using paired sample Students' t-tests. The level of confidence was chosen as 95 % in the statistical analysis. So, it was assumed that there was a significant difference between groups, when p<0.05.

The means and standard deviations of skin temperature in each period in both the control and schizophrenia groups are shown in Table 2.

Skin Temperature	*Control Group (°C)*			
	R1	WN	M	R2
Minimum	31.18	31.17	30.95	30.75
Maximum	34.69	34.83	34.87	35.02
Mean	33.24	33.29	33.35	33.41
Std Deviation	1.10	1.14	1.18	1.22
Skin Temperature	*Schizophrenia Group (°C)*			
	R1	WN	M	R2
Minimum	30.23	30.19	30.02	29.99
Maximum	35.87	35.91	35.98	35.94
Mean	33.73	33.85	33.93	33.98
Std Deviation	1.31	1.34	1.36	1.36

(R1: resting1, WN: white noise, M: music, R2: resting2)

Table 2. Skin temperature changes in each period

Figure 2 illustrates the changing pattern of mean skin temperature values in each period in both the control and the schizophrenia group. Clearly patient group has a higher skin temperature value than controls in all periods.

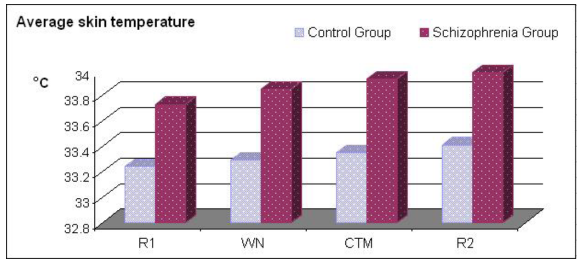

Figure 2. Average skin temperature in all steps

Our results showed that there is an increase in the mean of skin temperature in the schizophrenia group (p=0.005) while white noise exposure. This increase continued in the CTM period (p=0.01). The highest skin temperature value measured in R2 period in the schizophrenia group. Results indicated that there is a significant increase (p=0.002) in the skin temperature values between R1 and R2 periods. On the other hand, in the control group white noise exposure caused an insignificant (p=0.12) increase after first baseline. But, CTM stimulus after white noise caused an increase (p=0.05) in the average skin temperature value. Similar to the schizophrenia group, control group reported the highest skin temperature value in R2 period. The skin temperature response shows a significant increasing (p=0.04) pattern from R1 to R2 periods. Table 3 shows the standard deviations and mean values of the skin conductance (SC) responses between each step. In order to evaluate whether or not the auditory stimuli have an effect on SC, average differences between each step calculated and illustrated in Figure 3 as using the notations WN-R1, CTM-R1, R2-R1 and CTM-WN. Average skin conductance level increased with auditory stimuli in both groups. We reported a much more increase in SC while listening to CTM in the controls (p<0.05). Also, a decrease in SC in both groups in the post-stimulation period according to stimuli was found.

SC	*Control Group (µSiemens)*			
	WN-R1	M-R1	R2-R1	M-WN
Mean	0.0247	0.0459	0.0076	0.0212
Std Deviation	0.001	0.007	0.003	0.008
SC	*Schizophrenia Group (µSiemens)*			
	WN-R1	M-R1	R2-R1	M-WN
Mean	0.0228	0.0304	0.0151	0.0075
Std Deviation	0.005	0.006	0.004	0.002

(WN-R1: white noise-resting1, M-R1: music-resting1, R2-R1: resting2-resting1, M-WN: music-white noise)

Table 3. Skin Conductance changes in each period

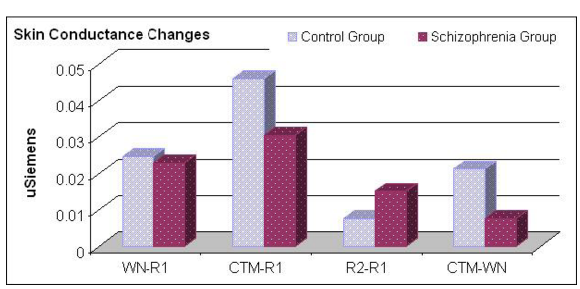

Figure 3. Comparison of skin conductance changes

Figure 4 shows the correlation between skin conductance and skin temperature changes in the control and schizophrenia groups. As the skin temperature increased while stimuli periods, in both groups skin conductance value increased, too.

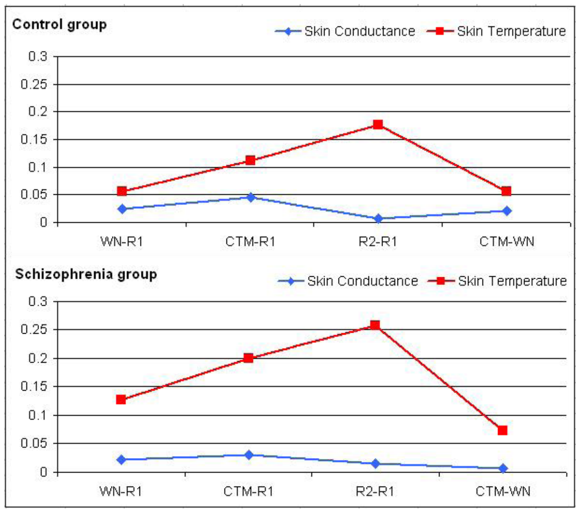

Figure 4. Correlation between skin conductance and temperature in the control and patient groups

Although the skin temperature of schizophrenics measured higher than controls while listening to white noise, their skin conductance value found as similar as controls. On the other hand, while CTM exposure causes a much more temperature increase in the patient group, the skin conductance of schizophrenics measured lower than the control group. Figure 5 shows the average values of power spectral densities (PSD) of the skin conductance signals in both groups. In all the periods of the procedure controls responses found higher than schizophrenics. It was found that PSD of skin conductance of during listening CTM is higher than all other steps in the control group ($p < 0.05$). Besides, the average PSD values of skin conductance during listening white noise, which includes rain sounds, show a similar pattern as it has a value during listening CTM in the schizophrenia group. Responses of the two resting states are very near and show small values of PSD.

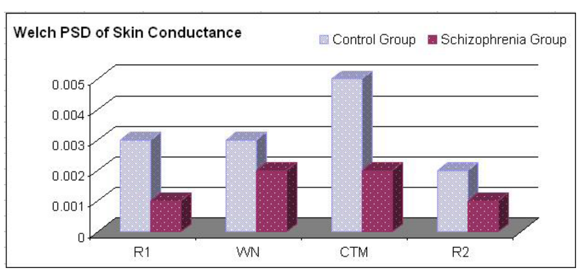

Figure 5. Average of power spectral densities of skin conductance values in schizophrenia and control groups

4. Discussion

The galvanic skin response (GSR) is a simple, useful and reproducible method of capturing the autonomic nerve response as a parameter of the sweat gland function. Physically, GSR is a change in the electrical properties of the skin in response to different kinds of stimuli. In general auditory stimuli preferred. Some experiments are conducted using different kinds of music for an auditory stimulus.

The effects of music upon GSR in normals and schizophrenics have been studied in lots of experiments [15-17]. It was found in the previous studies that the exciting music produced a decrease, the calming music an increase and the neutral music no change in electrical resistance. Numerous investigators [18] demonstrated that skin resistance fluctuates inversely with local skin temperature, but they were unable to draw any conclusions regarding the unpredictable relation of GSR amplitude to temperature. Under experimental conditions, as the skin temperature increases, skin resistance decreases.

Peripheral temperature is an indirect index of peripheral vasoconstriction. Measured by sensors placed on the finger, temperature is a useful measure and training protocol in such conditions as diabetes mellitus, migraine, Reynaud's disease, and stress reactivity [19]. Events that take place in the brain influence skin temperature, just like they influence other characteristics. A peripheral response, like a change in skin can be considered an indicator of the cognitive state. The important factors that affect skin temperature are environmental conditions, individual factors and emotional or physiological state. Given that the first two factors remain constant, skin temperature can vary by 1-2 degrees Fahrenheit depending upon the emotional state of a person.

In the present study, two experiments, one using healthy controls and the other using schizophrenic patients, were conducted to investigate that the effect of the CTM in electrical conductance (inverse of resistance) of the skin and the skin temperature. Our study confirms that there is a difference in terms of ANS responses between schizophrenics and healthy controls. Although schizophrenic patients had greater values of skin temperature, healthy subjects exhibited greater skin conductivity in response to the white noise and CTM exposure than did patients. Moreover, both controls and patients also exhibited significantly more skin conductivity to CTM than to white noise (Figure 3) possibly as a result of a decreased parasympathetic activity. In other words, it was found for both the control and schizophrenia groups that the decrease in skin resistance due to the white noise and music. The changes in skin conductivity are interpreted as due to the emotional effects produced by the stimulus. Specifically, despite greater skin temperature, the pattern of schizophrenics' skin conductance responses found as near as controls in the white noise period (Figure 4). This finding appears consistent with results of previous studies in which 40% to 60% of schizophrenic patients have depressed electro dermal activity as indicated by a failure to respond to stimuli, the presence of low skin conductance level [20].

Most of the GSR studies have been concerned with the normal values of response amplitude and latency. Here, the power spectral density values of the GSR signal were evaluated. So, the spectral estimation of GSR was investigated. Despite it has a higher value than the baseline periods, average power spectral densities of skin conductance during listening acoustic white noise and listening CTM found as similar in the schizophrenia group (Figure 5).

In the light of our findings, CTM causes a more decrease in skin resistance, which is an index of person's stress in controls. It remains unclear whether schizophrenics' skin conductance change is specific to CTM or white noise. An explanation for this situation is that schizophrenic patients have trouble with processing emotional information. Although white noise preferred as a neutral and CTM as a positive stimulus in our study, this difference could not have evaluated by schizophrenia patients. In conclusion, these findings suggest that autonomic arousal for auditory stimuli in schizophrenic individuals are remarkably different from healthy individuals. The use of skin conductivity in response to CTM is the first attempt of which we are aware of measure ones stress level without using some anxiety scales in psychiatry. Future research should include negative stimuli in addition to neutral (white noise) and positive (CTM) stimuli. Nonetheless, the findings of this study should be extended by investigators using other types of stimuli and other kinds of electrophysiological measures to investigate the effects of CTM.

5. Acknowledgements

This project was supported by Fatih University Research and Development Management Office with the project number of P50060901.

References

[1] American Psychiatric Association (2000). Diagnostic and Statistical Manual of Mental Disorders: DSM-IV, Washington DC.

[2] Freedman, R. (2003). Schizophrenia, *New England Journal of Medicine*, 349. 1738-1749.

[3] Nuechterlein, K.H., Dawson, M.E. (1984). A heuristic vulnerability/stress model of schizophrenic episodes, *Schizophrenia Bulletin*, 10. 300-312.

[4] Zubin, J., Spring, B. (1977). Vulnerability: A new view of schizophrenia, *Journal of Abnormal Psychology*, 1977, 86. 103-126.

[5] Serban, G. (1975). Stress in normals and schizophrenics, *British Journal of Psychiatry*. 126 . 397-407.

[6] Vernet-Maury, E. (1991). The cutaneous bio-electrical signals and their sources, *ITBM*, 12. 98-111.

[7] Guyton, A.C. (1991). Textbook of Medical Physiology, Bangalore: Prism Books Pvt Ltd.
[8] Geddes, L.A., Baker, L.E.(1975). Principles of Applied Biomedical Instrumentation, John Wiley & Sons Inc; 2nd Revised edition.
[9] Bernal, M.E., Miller, W.H. (1971). Electrodermal and cardiac responses of schizophrenic children to sensory stimuli, *Psychophysiology*, 7. 155-168.
[10] Sudheesh, N.N., Joseph, K.P. (2000). Investigation into the effects of music and meditation on galvanic skin response, *ITBM-RBM*, 21. 158-163.
[11] Karakas, S., Gurbuz, O., Baran, Z. (2008). The effects of Classical Turkish Music on the oscillatory responses of the brain, *International Journal of Psychophysiology*.
[12] Kalender, R (1987). Türk Musikisinde Kullanılan Makamların Tesirleri *Ankara Üniversitesi Dergisi*, 29. 361-375.
[13] Pecchinenda, A., Smith, C. A. (1996). The affective significance of skin conductance activity during a difficult problem solving task, *Cognition and Emotion*. 10. 481-504.
[14] Welch, P.D. (1967). The use of fast fourier transform for the estimation of power spectra: a method based on time averaging over short modified periodograms, *IEEE Transactions on Audio and Electroacoustics*. 15. 70–73.
[15] Deltombe, T., Hanson, P., Jamart, J., Clerin, M. (1998). The influence of skin temperature on latency and amplitude of the sympathetic skin response in normal subjects, Muscle and Nerve. p. 34-39.
[16] Zhai, J., Barreto, A.B., Chin, C., Li, C (2005). Realization of Stress Detection using Psychophysiological Signals for Improvement of Human- Computer Interactions, *SoutheastCon*,. 415-420.
[17] Weidenfeller, E.W., Zimny, G.H. (1962). Effects of music upon GSR of depressives and schizophrenics, *Journal of Abnormal and Social Psychology*, 64. 307-312.
[18] Maulsby, R.L., Edelberg, R (1960). The interrelationship between the galvanic skin response, basal resistance and temperature, *Journal of Comparative and Physiological Psychology*, 1960. 53. 475-479.
[19] Schwartz, M.S., Andrasik, F (2003). Biofeedback: A Practioner's Guide, Guilford Press, 3rd edition.
[20] Katsanis, J., Iacono, W.G. (1994). Electrodermal activity and clinical status in chronic schizophrenia, *Journal of Abnormal Physiology*. 103. 777-783.