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Acoustic startle reflex in schizophrenia patients and their first-degree relatives: Evidence of normal emotional modulation

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Abstract

We investigated emotional disturbances in 36 schizophrenia patients, 48 of their first-degree relatives, and 56 controls to determine if abnormal affective startle modulation could be associated with genetic risk for schizophrenia. Both patients and relatives had a pattern of startle modulation indistinguishable from controls, with potentiated startle amplitude while viewing negative valence slides and attenuation while viewing positive slides. Patients with flat affect did not differ from those without in startle modulation or slide ratings. The patients and their relatives had lower pleasantness ratings of positive slides and the patients had higher pleasantness ratings of the negative slides than controls. The startle paradigm may not be useful for identifying individuals with a genetic liability for schizophrenia. The results suggest that low-level defensive and appetitive behaviors are unaffected in schizophrenia.

Descriptors: Schizophrenia, Genetic vulnerability, Flat affect, Emotion, Startle reflex, Negative symptoms

Affective disturbances have been emphasized as a key feature of schizophrenia since its early conceptualizations by Bleuler (1911/1950) and Kraepelin (1919/1971). These affective disturbances, generally affective flattening, have gained renewed interest due to the works of contemporary investigators (Andreasen, 1982; Crow, 1980) and have proved to have some prognostic utility (Carpenter, Bartko, Stauss, & Hawk, 1978; Fenton & McGlashan, 1991; Knight & Roff, 1985). In addition, there is evidence from twin studies that the affective symptoms of schizophrenia are more heritable than positive psychotic symptoms (Dworkin & Lenzenweger, 1984).

The assessment of affective disturbances has taken several forms. Most of the work in the field of schizophrenia has focused on either self-report measures, such as the physical anhedonia scale (Chapman, Chapman, & Raulin, 1976), or negative symptom rating scales, which include assessment of affective flattening (e.g., scale for the assessment of negative symptoms [SANS]; Andreasen, 1981). However, because rating scales of affective disturbances are often done in the context of a clinical interview, it is easy to inadvertently rate behaviors related to interpersonal style and personality that are unrelated to true affective disturbances (Dworkin, 1992). Studies using objective indices of emotional state, such as coded facial expressions, and corrugator (eyebrow) and zygomatic (cheek) electromyography, followed, and these studies have generally found that schizophrenia patients show less expressivity during evocative conditions (Berenbaum & Oltmanns, 1992; Kring, Kerr, Smith, & Neale, 1993; Mattes, Schneider, Heimann, & Birbaumer, 1995; Sison, Alpert, Fudge, & Stern, 1996; but for a review see Neale, Blanchard, Kerr, Kring, & Smith, in press). These same studies suggest that although expressive behaviors may be affected in schizophrenia, emotional experience may remain intact.

The current study used the startle reflex paradigm as a probe of emotional state. This paradigm measures the amplitude of the eyeblink reflex triggered by a loud acoustic probe. The eyeblink is generally measured by electromyographic electrodes placed just beneath the eye to record the bioelectric potentials resulting from the *orbicularis oculi* muscle contraction. The startle eyeblink is the most sensitive component of the startle response, which is a whole-body response, and has the additional advantage of slow habituation. Nonpsychiatric controls have been shown to modulate the amplitude of the reflex as a function of emotional state (Lang, 1995). Studies by Lang and colleagues (Bradley, Cuthbert, and Lang, 1990; Lang, Bradley, & Cuthbert, 1990) have demonstrated that while persons are viewing slides that are unpleasant in valence (i.e., threatening and grotesque images), the amplitude of the startle eyeblink reflex is augmented. While viewing slides that are pleasant in valence (i.e., erotic, joyful, and exciting images), the amplitude of the startle eyeblink reflex is reduced. Because of these studies, it has been argued that modulation of the startle reflex is a reliable probe of active emotional state. It is thought that

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the congruence between being in an aversive affective state and the aversive acoustic probe causes the augmentation of the startle reflex, whereas it is the incongruence between being in an appetitive affective state and the aversive probe that causes a reduction in the amplitude of the startle reflex (Lang, 1995).

Although the startle reflex paradigm is subject to the same criticism as other laboratory-based measures regarding generalizability to broader symptom domains, this paradigm may afford more reliable and controlled assessment of provoked emotional states. Psychophysiological assessment of emotion has several advantages over self-report and interview-based measures in that psychophysiological assessment is not subject to voluntary distortion and is easily quantified. The desirability of an objective measure of emotional processing is great given the difficulties in the assessment of emotion and is especially so within a compromised population such as persons with schizophrenia. Indeed, self-report measures of emotion should be viewed with some skepticism given that schizophrenic patients are not always reliable informants of their experiences (Jaeger, Bitter, Czobor, & Volavka, 1990).

There has been only one published study of affective modulation of the startle reflex in schizophrenia (Schlenker, Cohen, & Hopmann, 1995). In this study, the patients with schizophrenia had equal magnitude startle reflex amplitudes while watching negative and neutral slides. However, these patients showed a reduction in the magnitude of the startle reflex while watching positive valence slides. These data indicate that the patients with schizophrenia do not have the normal augmentation of the startle reflex while watching negative valence slides. The authors also divided the patients with schizophrenia into two groups based on ratings of flat affect. Contrary to expectation and the author's predictions, the patients with flat affect showed the *normal* pattern of startle reflex modulation, whereas the patients that were classified as having no affective flattening showed an *abnormal* startle amplitude pattern with a reduction in the reflex amplitude while watching both positive and negative slides.

The purpose of the present study was to use the affect startle paradigm as a tool to assess emotional dysfunction in schizophrenia. In addition, the utility of the using the paradigm to identify individuals at an increased risk for schizophrenia (i.e., first-degree relatives) was also investigated. Because of the many reports of disturbed emotion in schizophrenia, especially flat affect, it was predicted that patients with schizophrenia would show a pattern of startle responses indicative of diminished modulation. It was also predicted that the relatives would show a similar pattern of diminished modulation. The support for the latter prediction comes from two sources. First, based on self-report and interview measurements, relatives of schizophrenic probands have been shown to have emotional disturbances (e.g., anhedonia) reflective of the more severe emotional symptoms seen in schizophrenia (Clementz, Grove, Katsanis, & Iacono, 1991; Grove et al., 1991; Katsanis, Iacono, & Beiser; 1990). Second, a recent twin study indicated that modulation of the startle reflex may be heritable and under partial genetic control (Carlson, Katsanis, Iacono, & McGue, 1997). Assuming that the types of affective disturbances seen in persons with schizophrenia and their relatives are heritable and the modulation of the startle reflex is heritable, the startle paradigm could potentially be useful in the detection of individuals that carry a genetic risk for schizophrenia. In addition, the relationship between affective modulation of the startle reflex and symptomatology and severity of illness was also investigated. Contrary to the findings of Schlenker et al. (1995), it was predicted that a reduction in affective modulation of the startle reflex would be related to the presence, not absence, of affective flattening and more severe illness. This last prediction was based on studies that have shown that schizophrenic patients with clinically rated flat affect tend to be less emotionally expressive (Kring et al., 1993; Sison et al., 1996).

Method

Participants

Thirty-six schizophrenic inpatients were recruited from the acute-care psychiatric units of a regional hospital that serves a large metropolitan area. In addition, 48 biological first-degree relatives of the probands with schizophrenia were recruited. All participants were between the ages of 18 and 65 years, spoke English fluently, were not currently abusing drugs or alcohol, had not recently undergone electroconvulsive therapy (ECT) treatment, and had no history of neurological disease, systemic disease known to involve central nervous system (CNS) functioning, clinically significant head injury, or mental retardation.

Fifty-six nonpsychiatric control participants were recruited from the community via advertisement posters placed in multiple medical settings (e.g., general medical clinics, dental clinics, dermatology clinics, etc.) at the same hospital from which the patients were recruited. In addition, posters were placed at similar medical clinics in a university hospital and in several community vocational/technical schools in the region. Control participants were excluded using the same general and medical criteria that were used for the patients. Furthermore, they were interviewed to exclude those with the presence of lifetime diagnoses of any major affective, psychotic, or substance use disorder. Participants who reported that their first-degree relatives had received mental health treatment for any of these conditions were also excluded. Visual acuity was measured in all participants and those needing to wear corrective eyewear did. All participants provided written informed consent prior to the experimental session. Tables 1 and 2 provide demographic and clinical information of the study participants.

Clinical Assessment

All patients met DSM-IV (American Psychiatric Association, 1994) criteria for schizophrenia, based on diagnostic interviewing using the structured clinical interview for DSM-IV (SCID, Modules A–E; First, Spitzer, Gibbon, & Williams, 1995) and chart reviews. Nonpsychiatric control participants and the relatives of the patients with schizophrenia were also interviewed with the SCID. To confirm diagnostic assignments, a consensus diagnostic team composed of advanced graduate students with extensive training in clinical interviewing and diagnosis reviewed the SCID and chart data.

Table 1. *Participant demographic characteristics*

Group	*n*	Gender (M/F)	Age in years ($M \pm SD$)	Years of education ($M \pm SD$)
Schizophrenia	36	27/09[r,c]	32.6 ± 08.9[r]	12.5 ± 1.9[r,c]
Relative	48	19/29	39.2 ± 12.1	13.7 ± 2.0[c]
Control	56	23/33	38.0 ± 13.5	15.7 ± 2.2

Note: r = significantly different from the relative group; c = significantly different from the control group.

Table 2. *Clinical status of schizophrenia patients*

Feature	*M* ± *SD*
Global Assessment of Functioning Scale	25.6 ± 06.13
Age of illness onset (in years)	23.8 ± 06.74
Duration of illness (in years)	12.1 ± 09.42
Number of hospitalizations	11.2 ± 11.89

Indices of positive and negative symptoms were derived from information collected using the SCID and consisted of simple symptom counts. The positive symptom index was equal to the number of Module B items coded "present" regarding referential, persecutory, grandiose, somatic, and religious delusions, delusions of being controlled, thought broadcasting, and auditory, visual, tactile, gustatory, and olfactory hallucinations. The negative symptoms index was composed of Module B items coded "present" regarding avolition, alogia, and affective flattening. Illness severity during the worst week of the preceding month was quantified with the DSM-IV global assessment of functioning scale.

Startle Assessment

Electromyographic (EMG) activity was recorded from two small, 0.5 cm, Ag-AgCl electrodes filled with electrode paste. The two electrodes were attached with adhesive electrode collars to the skin covering the *orbicularis oculi* muscles of the right eye. One electrode was placed directly below the pupil and the other was placed to its lateral side, up slightly toward the outer canthus. A ground electrode was placed on the right shin. All electrode impedances were kept below 10 kΩ.

EMG signals were recorded by a Grass Model 7E polygraph and digitized at a rate of 1,024 samples per second. Raw EMG data were filtered through a 100-Hz low pass filter and a 10-kHz high pass filter and then rectified online using a Coulbourn Contour Following Integrator with a nominal time constant setting of 100 ms.

The startle paradigm procedures used were patterned after Bradley, Cuthbert, & Lang (1990) and were identical to the procedures of Carlson et al. (1997), including use of the same slides.[1] All participants were seated comfortably in a darkened room and were shown a series of photographic slides (Center for the Study of Emotion and Attention, 1998) projected on a large projector screen approximately 190 cm from the subject. One-third of the slides had been assigned to each of the three affective valence categories (positive, neutral, or negative) based on the ratings provided by the international affective picture system (IAPS; Lang, Bradley, & Cuthbert, 1998). Positive slides included pictures of money, cute animals, thrilling/dangerous sports, and erotic nudes. Neutral slides included pictures of everyday items (e.g., umbrella, rolling pin). Negative slides included personally threatening pictures (e.g., pointed gun, coiled snake) and grotesque pictures (e.g., mutilated body). Again, based on the IAPS normative ratings, the neutral slides chosen had low (<4) arousal ratings and pleasure ratings near the midpoint of the scale (5–6). Positive and negative slides were chosen that had high (>6) arousal ratings. Positive slides had high pleasure ratings (>6) and negative slides had low pleasure ratings (<4). Slides in which the IAPS normative ratings indicated significant sex differences in ratings were not used because a single slide show was used. Slide order was held constant across participants, with an equal number of slides from each valence category appearing in a pseudorandom order in each third of the task. A Kodak Ektagraphic III AMT projector displayed each slide for 6 s. A Vincent Uniblitz model D122 shutter driver controlled the slides. Interslide intervals were random, but fell between 10 and 20 s.

The acoustic startle probe, a 50-ms burst of 90-dB noise with instantaneous rise and fall times, was produced by a Coulbourn white noise generator. The probes were presented binaurally through Sennheiser HD845 headphones on two-thirds of the trials for each valence category. To allow time for processing slide content, the startle probes were introduced at random times from 2 to 5 s after slide onset. Eight additional startle probes were introduced during the interslide interval to increase the unpredictability of probe occurrence. Participants were instructed to ignore the startle probes and focus their attention on the slides at all times. Participant behavior was monitored via a Panasonic infrared camera to make sure the experimental instructions were followed. Participants were instructed to pay close attention to the slides, sit still, and keep their eyes on the viewing screen. They were told that we were interested in measuring their body's responses to the slides. After the entire slide presentation, participants viewed the slides again in the same order and were asked to rate how pleasant or unpleasant the slides made them feel using a pencil-and-paper version of the self-assessment manikin (SAM; Lang, 1980). The SAM has a 9-point scale measuring valence, with 9 being most positive, 5 neutral, and 1 most negative. Because participants were instructed to rate how the content of the slide made them feel, the slide ratings most likely reflect subjective emotional experience.

EMG data were scored offline. Startle EMG peak amplitude was calculated, in arbitrary digital units, for all segments immediately following the acoustic probes. EMG amplitude was quantified by subtracting the peak-integrated EMG response in the 150-ms interval following a probe from the integrated EMG just before probe onset.

To minimize unwanted differences between participants in range of EMG response amplitude, due to potential physiological or equipment-related factors, EMG amplitude was measured in arbitrary digital units instead of microvolts and was range corrected (Carlson et al., 1997). Each participant's EMG responses were rescaled as a percentage of each participant's maximum EMG response to the task probes (Lykken, Rose, Luther, & Maley, 1966).

Statistical Analysis

To reduce the number of false positives in the repeated measures analyses of variance (ANOVAs) described below, the Greenhouse–

[1] The IAPS identification numbers for the slides used, in order of presentation (+: positive; =: neutral; −: negative; *: probed) are 550 (=*), 803 (+), 139 (=), 626 (−*), 818 (+*), 925 (−), 808 (+*), 709 (=*), 960 (−*), 171 (+*), 706 (=*), 241 (=), 623 (−*), 705 (=*), 165 (+*), 905 (−), 991 (−*), 849 (+), 104 (−*), 615 (=*), 8501 (+*), 837 (+), 750 (=), 303 (−*), 981 (−), 830 (+*), 713 (=*), 637 (−*), 466 (+), 701 (=*), 468 (+*), 130 (−*), 700 (=), 635 (−), 715 (=), 469 (+*). The first 61 participants (first sample) recruited for study were presented the first 27 slides listed above. The subsequent 79 participants (second sample) were presented with all 36 of the listed slides. All methods, including the order of the slides and which slides were probed, remained identical for the two samples. The only difference was the addition of the extra 9 slides. The extra slides were added to include more erotic and threatening stimuli because this class of picture typically results in the most modulation of the startle reflex (Balaban & Taussig, 1994; Lang, 1995). Results from analyses of the two samples separately were the same as when combined. In addition, using just the first 27 slides instead of all 36 in the second sample had no effect on the significance of the statistical tests. Therefore, both samples were combined for all reported analyses.

Geisser epsilon-correction procedure was used to adjust the degrees of freedom. The F tests presented below, which used repeated measures, included the unadjusted degrees of freedom together with the value of epsilon associated with the error term and the corrected p value. A p value less than .05 was required for the results of a statistical test to be considered significant. Significant F tests were followed, as appropriate, by univariate ANOVAs, post hoc planned contrasts for effects that were expected based on the extensive startle literature, and Bonferroni-corrected contrasts to control for type I error when no specific hypothesis was present. Although startle eye blink data were available for all participants, data were missing on as many as 13 participants for some of the other variables. This fact is reflected in the reported degrees of freedom for specific statistics.

Because the startle amplitude data were range corrected, group main effects derived from analyses of these data cannot be used to determine if the groups differed in the absolute magnitude of their startle reactions. Hence, the key effects of interest are the group by valence interactions, which tested whether the groups differed in their pattern of startle amplitude modulation.

Results

Several preliminary analyses were carried out to determine how similar the groups were on selected demographic characteristics (see Table 1) and the degree to which these characteristics were related to startle amplitude. The proportion of males differed across groups, $\chi^2(2, N = 140) = 12.75$, $p < .01$, with the proportion of men in the schizophrenia group significantly larger than the proportion in either of the other two groups which did not differ. The presence of an age effect, $F(2,138) = 3.45$, $p < .05$, reflected the fact that the patients were significantly younger than their relatives but not the nonpsychiatric controls, and that the relative and control groups did not differ. With regard to years of education, each of the three groups differed significantly from the other two, $F(2,130) = 39.04$, $p < .001$. With participants collapsed into a single group, a Gender × Valence (positive, neutral, negative) repeated measures multivariate ANOVA (MANOVA) was carried out to determine if startle amplitude was related to gender. This analysis failed to reveal either a main effect for gender, $F(1,138) = 0.01$, or a significant Gender × Valence interaction, $F(2,137) = 2.1$, $\epsilon = 0.94$. Pearson correlational analyses indicated that neither age nor years of education was correlated with EMG startle amplitude for any of the valence conditions (range of r values, $-.11$ to $.17$). Given these negative findings, gender, age, and education were not considered in the remaining analyses.[2]

Startle Response Amplitude

As Figure 1A illustrates, the pattern of startle modulation was virtually identical across groups. A Group (schizophrenia, relative, and control) × Slide valence (positive, neutral, and negative) repeated measures MANOVA with startle response amplitude as the dependent variable indicated no group main effect, $F(2,137) = 0.20$, or group by valence interaction effect, $F(4,272) = 1.05$. However, the main effect for valence was significant, $F(2,136) = 131.06$, $\epsilon = 0.94$, $p < .001$. Planned comparisons were carried out to determine if, as expected, the positive slides produced the smallest and the negative slides the largest responses, with the neutral slide response amplitudes falling between these values. The results showed that for each group, the neutral slides produced significantly larger responses than the positive slides, and the negative slides produced significantly larger responses than the neutral slides. Hence, although there were no group differences in emotional modulation of the startle reflex, all three groups showed the prototypic pattern of startle modulation.

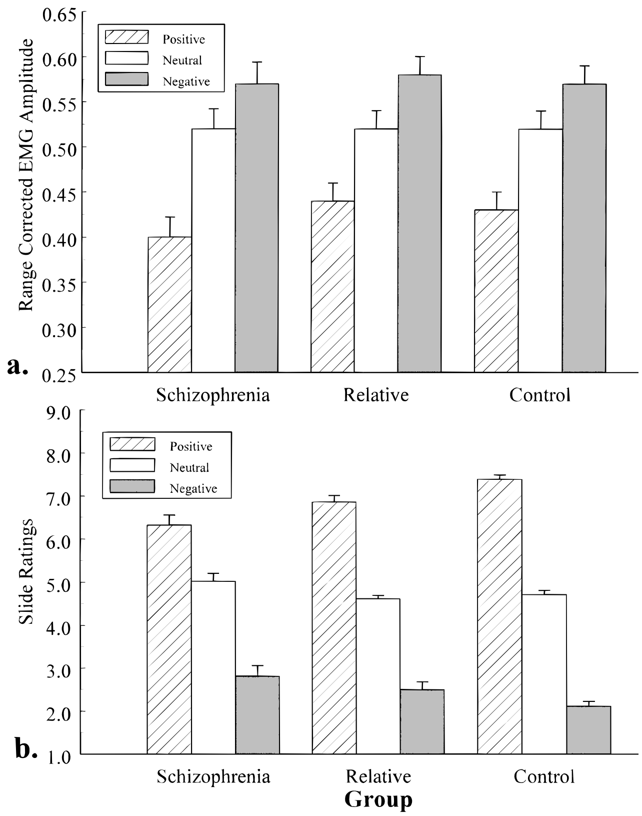

Figure 1. (A) Range corrected electromyographic (EMG) amplitude as a function of group membership and slide valence. Each bar depicts the mean and standard error. (B) Slide ratings for the three groups. Each bar represents the mean and standard error for the slide ratings for each of the three slide valence conditions for each group. Higher scores represent more pleasant ratings and lower scores represent more unpleasant ratings.

Slide Valence Ratings

Slide ratings were not available on 13 participants (5 of whom were schizophrenia patients, 5 were relatives, and 3 were controls) due to equipment-related problems and participants misunderstanding the rating instructions. Ratings of slide valence made by the participants confirmed the pretask assignment of slides to the three valence conditions based on ratings in the IAPS manual (Lang et al., 1998). A Group (schizophrenia, relative, and control) × Pretask slide valence (positive, neutral, and negative) repeated measures MANOVA with ratings of slide valence as the dependent variable indicated that there were no significant differences among groups in slide ratings, $F(2,124) = 0.24$. The main effect for valence was significant, $F(2,123) = 706.85$, $\epsilon = 0.74$, $p < .001$, as was the Group × Valence interaction, $F(4,246) = 10.71$, $p < .001$. Planned contrasts comparing the mean slide ratings for each condition indicated that, for each group, the positive slides were

[2] All the analyses reported in the results were also carried out using education and age as covariates. None of these analyses generated a result that altered whether a reported statistic was significant at the .05 level.

rated more pleasant than the neutral slides, which were rated more pleasant than the negative valence slides. Thus, the valence ratings made by the participants confirmed our pretask assignment of slides to the three valence conditions (Figure 1B).

To further investigate the Group × Valence interaction effect for the slide ratings, one-way ANOVAs, with follow-up Bonferroni contrasts, were computed with group status as the independent variable and the mean ratings for each slide valence condition as the dependent variable. There was a significant effect of group on the rating of positive slides, $F(2,124) = 11.30$, $p < .001$. Post hoc tests indicated that the schizophrenic patients and the relatives, who did not differ significantly from each other, rated the slides less pleasant (or more unpleasant) than the controls. The effect of group was nonsignificant for the neutral slide ratings, $F(2,124) = 2.96$, but was significant for the negative slide ratings, $F(2,124) = 4.17$, $p < .02$. Follow-up analyses indicated only that the patients with schizophrenia rated the negative slides less unpleasant (or more pleasant) than the controls.

Medication Effects

The potential effects of patient medication status on startle modulation were investigated. Medication type (on, off) by slide valence repeated measures MANOVAs indicated that there were no medication effects on EMG startle modulation for patients on atypical antipsychotics ($n = 25$), typical antipsychotics ($n = 11$), anxiolytics ($n = 5$), antidepressants ($n = 7$), mood stabilizers ($n = 22$), antiparkinsonian agents ($n = 12$), or nicotine (i.e., patch or gum; $n = 6$). Although it has been reported that medications, especially anxiolytics (Patrick, Berthot, & Moore, 1996), may have an effect on the startle reflex, we found medication status to be unrelated to startle amplitude modulation in this study.

Associations With Clinical Features

Among the schizophrenia patients, various analyses were conducted to test whether variability in the degree of modulation of the startle reflex might be related to meaningful clinical variables, which included positive and negative symptoms and severity of illness. Pearson correlational analyses, using a modified Bonferroni correction that controls for the number of statistical tests performed without being overly conservative (Holland & DiPonzio Copenhaver, 1988), indicated that the number of negative symptoms, positive symptoms, flat affect, and ratings of illness severity was unrelated to the startle reflex amplitudes, regardless of slide valence condition (Table 3).

Because of its theoretical relevance, affective flattening was analyzed separately. A Flat affect (absent, present) × Slide valence (positive, neutral, negative) repeated measures MANOVA indicated that the schizophrenic patients with flat affect ($n = 8$) showed a startle reflex pattern similar to the patients without flat affect ($n = 28$). Neither the group effect, $F(1,34) = 0.52$, nor the Flat affect × Slide valence interaction was significant, $F(2,33) = 1.39$, $\epsilon = 0.78$ (see Figure 2A). An additional MANOVA, comparing the slide ratings between schizophrenic patients with and without flat affect revealed no group differences in how they rated the slides, $F(1,21) = 1.54$. In addition, the interaction between flat affect and valence was not significant, $F(2,20) = 0.17$, $\epsilon = 0.59$ (See Figure 2B). Hence, the modulation of startle reflex amplitude was unrelated to positive symptoms, negative symptoms in general, and severity of illness, and the presence or absence of flat affect was unrelated to the patient's slide ratings.

Based on the slide ratings, which provided a subjective assessment of emotional experience, the overall pattern observed was consistent with a reduction or restriction of self-reported emotional experience in the patients with schizophrenia. These results beg the question of whether the patients with schizophrenia who subjectively evaluated the slides as less emotionally potent also showed objective evidence of less modulation of the startle reflex. Analyses were conducted to test this interesting hypothesis. Pearson correlations were computed between the *objective* startle EMG amplitudes and the *subjective* slide ratings separately for the slides in each of the three valence categories. None of the correlations was significant (all rs $< .15$ and ps $> .28$, within each group and

Table 3. *Correlations between startle EMG amplitude and clinical variables for the schizophrenia patients*

Valence condition	Global assessment of functioning	Negative symptom index	Flat affect	Positive symptom index
Positive	−.11	.25	.23	.30
Neutral	−.18	.07	.04	.25
Negative	−.31	.01	.03	.24

$n = 36$.

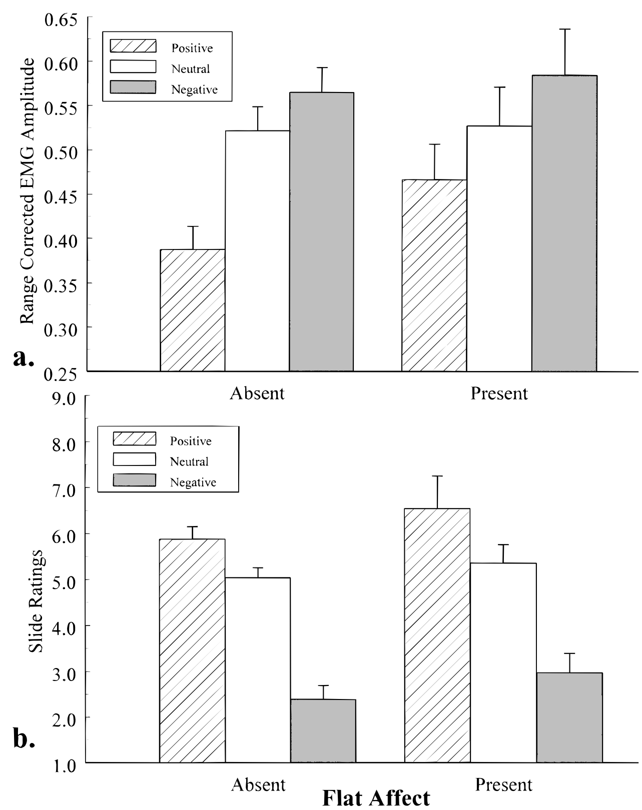

Figure 2. (A) Range corrected electromyographic (EMG) amplitude in the schizophrenia patients split into those with and without flat affect as a function of slide valence. The bars depict means and standard errors. (B) Slide ratings for schizophrenia patients with and without flat affect. Each bar represents the mean and standard error for slide ratings for each of the three slide valence conditions. Higher scores represent more pleasant ratings and lower scores represent more unpleasant ratings.

with all participants collapsed into a single group). Overall, there were no discernible relationships between the subjective ratings of the slides and the objective EMG measures of emotional modulation of the startle reflex. Nor was there a relationship between slide valence ratings and clinical ratings of flat affect.

Discussion

The current study used the affect startle paradigm to assess emotional reactivity in schizophrenia. In addition, the utility of using the paradigm to identify individuals at an increased risk for schizophrenia (i.e., first-degree relatives) was also investigated. The schizophrenic and relative groups had a pattern of affective modulation of the startle reflex that was comparable to the nonpsychiatric control group. All three groups demonstrated the typical modulation pattern in which startle amplitude was attenuated while watching positive valence slides and augmented while watching negative valence slides. Because the schizophrenia and relative groups were no different from the control group in startle reflex modulation and all groups modulated their startle reflex in the prototypical pattern, it can be argued that appetitive and aversive motivational systems thought to be responsible for the reflex modulation (Lang, 1995) are unaffected in schizophrenic patients and their relatives. Thus, our proposition that this paradigm could provide a potentially useful measure of emotional dysfunction for purposes of identifying persons at risk for schizophrenia was clearly not supported. Nonetheless, our findings are important because they provide information regarding the boundaries of emotional dysfunction in schizophrenia. Basic, low-level defensive and appetitive behaviors mediated by subcortical circuitry (Davis, 1989) appeared to be unaffected in schizophrenia. It can be concluded that patients with schizophrenia do “experience” emotional states, at least at a lower level that is not subject to voluntary control. Otherwise, the normal pattern of startle reflex modulation reported here would not be expected.

Although emotional reactivity based on modulation of an involuntary reflex seems unimpaired in schizophrenia, voluntary, subjective ratings of the slides revealed that both the patients with schizophrenia and the relatives rated positive slides less pleasant than the controls. In addition, the schizophrenic patients, but not the relatives, rated the negative slides less unpleasant than the controls. These findings suggest that, based on self-reported, evoked emotional experience, schizophrenic patients and possibly their biological relatives experience a restricted range of emotion. Not to be confused with flat affect, which is a symptom of schizophrenia based on a clinical rating of *expressive* behaviors, this finding is consistent with reports of anhedonia in schizophrenia and their relatives. Indeed, it was the more restrictive ratings of the positive slides that had the largest effect in the schizophrenia group and the only effect in the relatives. Although these findings may just as well represent increased negativity, which has also been reported among schizophrenic patients (Kring et al., 1993), the patients did not rate the negative slides less pleasant. Schlenker et al. (1995) found no group differences in slide ratings, but a recent study (Quirk, Strauss, & Sloan, 1998), that used a slide show similar to the one used in this study but did not include any psychophysiological indices of emotion, found that schizophrenic patients had lower pleasantness ratings for positive, negative, and even neutral slides. These discrepancies, along with studies finding no differences in self-reported emotional responses to evocative cues (e.g., Berenbaum & Oltmanns, 1992), suggest that more research is needed to clarify the conditions under which patients with schizophrenia report experiencing less emotion. Some studies have found that schizophrenia patients self-report *more* emotional experience (e.g., Kring et al., 1993).

Our analyses also indicated that there were no relationships between positive symptoms, negative symptoms, and severity of illness and the degree to which the schizophrenic patients showed emotional modulation of the startle reflex. Examining the impact of flat affect, specifically, indicated that those patients with clinically significant affective flattening showed a pattern of modulation indistinguishable from those without flat affect. There was also no difference in slide ratings. Thus, the patients with and without clinically significant flat affect, based on ratings of expressive behaviors, were indistinguishable on two measures of evoked emotional experience, one more reflexive and involuntary and the other more subjective and voluntary. This finding is intriguing and similar to other studies that have reported a disjunction between emotional experience and overt expressiveness (Berenbaum & Oltmanns, 1992; Kring et al., 1993; Kring & Neale, 1996; Sison et al., 1996). However, the symptom assessment used in the current study has certain limitations. A more formal symptom rating scale such as the SANS (Andreasen, 1981) was not used and instead, simple symptom counts from the SCID were used to quantify positive and negative symptoms. Using this classification scheme, only a quarter of the patients with schizophrenia were classified as having flat affect, which is lower than, for example, the 41% reported in the international pilot study of schizophrenia (World Health Organization, 1973). Participants were rated as having flat affect, as instructed in the SCID manual, only if the symptom was unmistakably present and clinically significant to a degree that the rater felt confident it was diagnostic. Therefore, the schizophrenic patients in this study who were classified as having flat affect were highly likely to possess this quality at a clinically significant level. Because these patients clearly showed the typical pattern of startle reflex potentiation and attenuation seen in nonpsychiatric participants, we feel that it is unlikely that some sampling or rating bias can account for these findings. Flat affect is typically rated in the context of a social interaction, such as an interview, whereas modulation of the startle reflex takes place within an experimental context in which the subject is alone, viewing pictures. Thus, one explanation for the disjunction between experience and expression is simply contextual. It may be the case that if startle probes could be delivered during provocative social interactions that varied in affective tone, or even during mental imagery, that the startle paradigm may be sensitive to the experiential deficits that the patients self-reported.

In summary, the results from the present study indicate that patients with schizophrenia and their first-degree biological relatives showed a normal pattern of emotional modulation of the startle reflex. However, there was evidence of a restricted range of subjective emotional experience in the schizophrenic patients and their biological relatives, which may represent anhedonia. This diminished range of subjective emotional experience was, however, not related to emotional modulation of the startle reflex. It is unclear why our results differ from those of Schlenker et al. (1995). However, we agree with these authors' conclusion that patients with schizophrenia seem to accurately perceive affective stimuli and respond, at least at an involuntary level, in a manner comparable to nonpsychiatric controls. Hopefully, this study can provide some insights into the nature of the emotional disturbances that have been reported in schizophrenia and those at risk for schizophrenia and the level at which these disturbances might manifest themselves.

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