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## Normative emotion-modulated startle response in individuals at risk for schizophrenia–spectrum disorders<sup>☆</sup>

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### Abstract

The nature of the affective deficit that characterizes social anhedonia is not well understood. Emotionally evocative visual stimuli were presented to undergraduates identified as anhedonic or normal, based on their scores on the revised Social Anhedonia Scale. The affective stimuli were chosen to elicit positive and negative emotion; a subset of slides were specifically chosen to include social–interpersonal content. In the acoustic startle paradigm, participants were administered startle probes (50-ms 95 dB white noise bursts) while viewing images from the International Affective Picture System. Socially anhedonic individuals did not differ from normally hedonic individuals in terms of their physiological response to the stimuli, regardless of the nature of the content of the stimuli. However, on the self-report measures of trait affectivity, the socially anhedonic individuals reported significantly lower levels of positive affect and higher levels of negative affect. These findings suggest that the affective deficits reported by socially anhedonic individuals are not global in nature. © 2002 Elsevier Science B.V. All rights reserved.

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### 1. Introduction

Anhedonia, the reduced ability to experience pleasure, has been hypothesized to be a core feature of schizophrenia (Meehl, 1962; Rado, 1962; Blanchard et al., 1998). Since Meehl's early writings, anhedonia has been posited as either a contributing or potentiating

factor in the development of schizophrenia. The Chapmans developed the Social Anhedonia Scale (Chapman et al., 1976; Eckblad et al., 1982) as a self-report measure to assess Meehl's (1962) descriptions of asociality.

Kwapil (1998) indicated that individuals with deviantly high scores on the revised Social Anhedonia Scale (Eckblad et al., 1982) are disproportionately more likely to develop a schizophrenia–spectrum disorder than controls. This finding suggests that the Social Anhedonia Scale independently predicts the development of schizophrenia–spectrum disorders. Comparative studies of social anhedonics and controls have indicated that the former group reports more psychotic-like experiences (Gooding et al., 1999), and is more likely to demonstrate neuropsychological

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(Gooding et al., 1999; Tallent and Gooding, 1999) and psychophysiological abnormalities (Gooding and Miller, 1998; Gooding, 1999; Gooding et al., 2000) displayed by many individuals with schizophrenia. Finally, Blanchard et al. (2000) applied taxometric procedures to the revised Social Anhedonia Scale and found evidence of a taxonic latent structure, consistent with the notion that this scale is an indicator of schizotypy. Taken together, these findings buttress support for further research interest in individuals reporting extreme levels of social anhedonia.

Social anhedonia, by definition, involves a deficit in affective experience. Individuals with anhedonia are purportedly hyporesponsive to pleasurable stimuli. According to Lang (1995), affective response can be measured in three different systems, namely, by subjective report, physiological reactivity, and behavioral actions. Presently, the nature of the affective deficit that characterizes social anhedonia is not well understood. The startle probe response is a useful measure for analyzing affective states (Vrana et al., 1988; Bradley et al., 1999).

### 1.1. *The startle paradigm*

The acoustic startle response in humans has behavioral plasticity, such that the response magnitude can be experimentally manipulated (Koch, 1999). Lang and others (c.f. Lang, 1995; Bradley et al., 1993) have used pictures to manipulate affective state. The magnitude of defensive eyeblink reflexes in response to auditory probes is typically greater in the presence of negatively valenced, highly arousing pictures compared to the reflexive response elicited during the presence of neutral, low-arousal pictures (Vrana et al., 1988). The magnitude of defensive eyeblink reflexes is attenuated during the presentation of positively valenced, highly arousing pictures relative to their magnitude during the presentation of neutral, low-arousal pictures.

Although there are no studies of socially anhedonic individuals' startle response, there have been a few studies of startle response in individuals with schizophrenia. Studies of individuals with schizophrenia (Schlenker et al., 1995; Curtis et al., 1999) indicate that schizophrenia is associated with normal affective modulation of startle. However, not all individuals with schizophrenia will have social anhedonia (Oli-

vares and Berrios, 1998). It is possible that an emotion-modulated startle deficit may only be apparent in schizophrenic individuals with social anhedonia. Studying socially anhedonic individuals on the startle paradigm may shed further insights into the relationship between social anhedonia and schizophrenia. According to a developmental conceptualization of schizophrenia (c.f. Gooding and Iacono, 1995), it is reasonable to assume that at least some of the socially anhedonic individuals are schizotypes, i.e. they possess the liability for the development of schizophrenia, and hence, those individuals would be expected to perform similarly to schizophrenia patients on the startle paradigm. However, given the observation that social anhedonia is predictive of schizophrenia-spectrum disorders, and not necessarily predictive of schizophrenia per se, individuals with social anhedonia may display somewhat different patterns from individuals with schizophrenia. Thus, the differences between putatively at-risk individuals and affected individuals may be as revealing as the similarities between the two groups.

To date, there have been no investigations of affective response in individuals reporting social anhedonia. The first objective of this study was to test whether the socially anhedonic individuals would fail to show the normative attenuation of the startle blink during the presentation of positive stimuli. Given Meehl's (1962) conceptualization of the construct, we expected that the difference between the normally hedonic individuals and the socially anhedonic individuals would be greatest when comparing the groups' response to positive stimuli with social-interpersonal content. We were also interested in determining whether individuals reporting social anhedonia would show affective modulation of the startle blink response in response to aversive or unpleasant stimuli. Assessment of the startle response enables us to investigate the nature and extent of affective deficits in socially anhedonic individuals.

The second aim of this study was to evaluate the relationship between social anhedonia and trait dimensions of anxiety, positive affect, and negative affect. Given that the Social Anhedonia Scale was developed to be independent of social anxiety, we expected that there would be little, if any, correlation between social anhedonia and social anxiety. In Meehl's (1962) conceptualization of hedonic capacity,

hypohedonia is related to aversive drift. Previous research (Blanchard et al. (1998)) has indicated that social anhedonia in schizophrenia was associated with low positive affect and high negative affect. Thus, in keeping with Meehl's early writings and Blanchard's findings, we hypothesized that social anhedonia would be inversely associated with positive trait affect and would be positively associated with negative trait affect.

## 2. Method

### 2.1. Participants

This was a nonclinical university sample drawn from English-speaking undergraduates at a large mid-western university. Subjects were selected from among the 962 males and 1362 females who completed a 179-item psychological questionnaire entitled "Survey of Attitudes and Experiences". The "Survey of Attitudes and Experiences" questionnaire was composed of a random mixture of all items from the Chapman Psychosis-proneness Scales, namely, Perceptual Aberration, Magical Ideation, revised Physical Anhedonia, and revised Social Anhedonia scales (Chapman et al., 1976, 1978; Eckblad and Chapman, 1983; Eckblad et al., 1982). In order to rule out random responding, we included the Chapman Infrequency Scale (Chapman and Chapman, 1983), a scale composed of infrequent items, and excluded any participants who endorsed three or more items.

One experimental group, the Social Anhedonia (SocAnh) group, and a control group were selected. The SocAnh group was made up of individuals who obtained scores at or beyond 2 SD from the same-sex sample mean on the revised Social Anhedonia Scale. The control group was comprised of a randomly selected set of individuals whose scores on all four Chapman scales were below 0.5 SD above the same-sex sample mean.

Following psychometric screening, subjects were invited to participate in a multiple-session study of "individual differences and brain functioning". Individuals who gave their informed consent were screened for personal or family history of emotional and/or physical conditions using a nonpatient version of the SCID (Spitzer et al., 1996) and a medical

history questionnaire. Any subjects who had a history of epilepsy, and/or traumatic brain injury were excluded from subsequent analyses. Potential participants were also screened for personal history of psychotic illness and/or any psychoactive substance use disorder. Participants were also screened for first-degree relatives with a psychotic illness, due to prior evidence (c.f. Gottesman, 1991) that individuals genetically related to a schizophrenia patient are at heightened risk for schizophrenia. Suggestive findings (Allen et al., 1999) that individuals with depressive disorder display aberrant emotional modulation of startle led us to also exclude any participants who met current diagnostic criteria for either Major Depression or dysthymia. Exclusions on the basis of current psychoactive substance use disorder or mood disorder resulted in our dropping two subjects from the control group and six subjects from the SocAnh group. Due to an insufficient number of startle responses and/or technical difficulties (see below), three (one SocAnh, two control) subjects were excluded from subsequent analyses. The final sample included 36 SocAnh (17 male, 19 female), and 39 control (20 male, 19 female) subjects. The means and standard deviations of the psychosis-proneness measures obtained from this study's screening sample are commensurate with those of previous Chapman samples (Chapman et al., 1980; Kwapil, 1996; Gooding, 1999). The resultant sample of psychosis-prone and control group participants also appears similar to other obtained samples; the means and standard deviations for each psychosis-proneness scale are provided in Table 1.

Table 1  
Group characteristics and Chapman Psychosis-proneness scale scores

Variable	Social anhedonia	Control
Gender	17 M/19 F	20 M/19 F
Age	18.97 (1.03)	18.95 (0.94)
Estimated IQ	114.28 (10.99)	117.49 (8.96)
Perceptual aberration	7.61 (6.15)	1.72 (1.82)
Magical ideation	9.53 (4.87)	4.13 (3.10)
Social anhedonia	21.22 (3.65)	3.56 (2.57)
Physical anhedonia	17.42 (9.20)	6.10 (3.11)

Means (standard deviations) are given for age, estimated IQ, and Chapman Psychosis-proneness scale scores. M = male; F = female.

## 2.2. Materials

The Chapman scales were designed to tap personality traits which indicate a predisposition to psychosis. The psychometric properties of these psychosis-proneness scales have been reported elsewhere (Chapman et al., 1995). The Perceptual Aberration Scale taps transient body image and perceptual distortions, with items such as “I have sometimes felt that some part of my body no longer belongs to me” (keyed true). The Magical Ideation Scale assesses belief in causality that is not valid (e.g. “Good luck charms don’t work”, keyed false).

The revised Social Anhedonia Scale measures social withdrawal, a lack of interest in social relationships and/or lack of pleasure derived from interpersonal relationships (e.g., “I sometimes become deeply attached to people I spend a lot of time with”, keyed false). The revised Physical Anhedonia Scale was designed to measure a deficit in the ability to experience pleasure. It included items such as “The beauty of sunsets is greatly overrated” (keyed true). The Chapman Infrequency Scale (Chapman and Chapman, 1983) was included to identify and eliminate those participants who responded randomly. It contained items such as “There have been times when I have dialed a telephone number only to find that the line was busy” (keyed false); we excluded any participants who endorsed three or more such items.

IQ was measured in order to provide further description of the undergraduate sample. Time constraints precluded the use of the entire revised Wechsler Adult Intelligence Scale (WAIS-R; Wechsler, 1981). Vocabulary and Block Design subtests were administered in order to obtain an estimate of participants’ full scale IQ. This two-subtest short form of the WAIS-R (Silverstein, 1982) yields scores that are highly correlated with full-scale scores, though they overestimate full scale IQ by an average of 2 points (Ryan et al., 1988).

Picture stimuli designed to elicit positive, negative, or neutral emotions were selected from Shows 1 through 11 of the International Affective Picture System (IAPS; Center for the Study of Emotion and Attention, 1994). Picture selection was based on consideration of valence, arousal, and content. Published self-report ratings of valence and arousal (Lang et al., 1993) were used to select positive, negative,

and neutral pictures.<sup>1</sup> In accordance with previous studies (c.f. Sutton et al., 1997; Larson et al., 2000), pictures were selected to ensure the following conditions: the negative pictures were high on ratings of arousal and low on ratings of valence; the positive pictures were high on ratings of valence and arousal; and the neutral pictures were low on arousal and average on valence.

In addition to the valence and arousal criteria, a subset of pictures were selected to include social and/or interpersonal content. There were a total of 63 slides, with equal numbers of slides in each of the three valence categories. The negative picture set depicted accident victims, mutilated bodies, and the aftermath of war. In the negative picture set, 10 of the 21 pictures contained social–interpersonal content, such as group scenes of violence. The positive pictures included depictions of money, sports scenes, and cute animals. In the positive picture set, 12 of the 21 pictures had social–interpersonal content, such as family scenes, opposite sex erotica, and heterosexual couples. The neutral pictures included flatware, household items, office furniture and buildings. None of the neutral pictures had social–interpersonal content. In order to best match the two genders on average valence and arousal ratings, slightly different picture sets were chosen for males and females. Table 2 lists the mean male and female valence and arousal ratings for the nonsocial and social picture sets.<sup>2</sup>

Each participant was individually administered a set of self-report questionnaires at the beginning of the experimental session. The Behavioral Inhibition/Activation Scales (BIS/BAS; Carver and White, 1994) were administered to examine activation of the two biobehavioral systems described by Gray (1994). The BIS/BAS Scales consist of 24 items (including four filler items) rated on a four-point Likert-type scale where 1 indicates “very true for me” and 4 indicates “very false for me”. The BIS scale assessed the strength of the behavioral inhibition system (coefficient alpha = 0.83 for present sample). The BAS Scale

<sup>1</sup> Valence ratings were made on a positive dimension so that low (positive) valence ratings reflect negative slides and high valence ratings reflect positive slides.

<sup>2</sup> The complete list of pictures used for the males and females are available from the corresponding author.

Table 2  
Mean (SD) male and female valence and arousal ratings for social and nonsocial picture sets

	Nonsocial picture set		Social picture set	
	Male	Female	Male	Female
<i>Valence</i>				
Negative	1.94 (0.29)	1.49 (0.37)	2.40 (0.26)	1.77 (0.30)
Neutral	4.92 (0.32)	5.02 (0.28)	–	–
Positive	7.35 (0.49)	7.34 (0.79)	7.44 (0.38)	7.58 (0.33)
<i>Arousal</i>				
Negative	6.23 (0.58)	7.01 (0.61)	6.35 (0.50)	6.78 (0.37)
Neutral	2.47 (0.49)	2.57 (0.38)	–	–
Positive	6.29 (0.67)	5.83 (0.79)	6.39 (1.01)	6.39 (0.61)

These ratings are from Lang et al. (1993).

consists of three subscales, namely, Reward Responsiveness, Drive, and Fun Seeking. The internal consistency reliability (coefficient alpha) for the BAS was moderate,  $\alpha = 0.77$ .

Trait positive affect and trait negative affect were measured with the trait version of the Positive and Negative Affect Schedule (PANAS-Trait; Watson et al., 1988; coefficient alpha = 0.84 for trait positive affect and 0.84 for trait negative affect among the present sample). The PANAS consists of 20 affect words, 10 positive (e.g. enthusiastic, active, proud) and 10 negative (e.g. irritable, frightened, ashamed). Participants are instructed to rate the extent to which they generally feel or experience each of the 20 emotions on a 5-point scale (1 = very slightly or not at all, 2 = a little, 3 = moderately, 4 = quite a bit, 5 = extremely).

The Activity Preference Questionnaire (APQ; Lykken et al., 1973; Lykken, 1978) was administered in order to obtain a nonobtrusive measure of trait anxiety (c.f. O'Leary et al., 1974). The APQ is a 74-item forced-choice questionnaire in which the participant is provided with two paired experiences and asked to choose the one which he imagines to be least unpleasant. For each item, an anxiety-provoking scenario involving either elements of physical danger or social embarrassment is paired with an onerous alternative. The physical anxiety scale measures apprehension of physical danger, whereas the social anxiety scale assesses social timidity. For the entire sample, the coefficient alpha for the social anxiety subscale

and the physical anxiety subscale was 0.81 and 0.86, respectively.

### 2.3. Apparatus and physiological recording

The electromyogram (EMG) was recorded from the orbicularis oculi using two miniature Ag/AgCl electrodes placed directly below the left eye. A third miniature electrode placed in the center of the forehead was used as ground. Electrode impedance was below 20,000  $\Omega$ . Using SAI Bioelectric amplifiers, the physiological signals were passed through band pass filters set at 1 and 800 Hz and amplified 10,000 times. After passing through a Rockland high pass filter set at 30 Hz, the raw signals were integrated and rectified. All signals were digitized and stored at 250 Hz using a 12-bit A:D board for off-line data analysis. The recording equipment was calibrated before and after each testing session.

### 2.4. Procedure

All participants received extra credit points for their participation. Administration of the self-report measures and the psychophysiological assessment were carried out by research assistants who were naive to group membership. All participants were tested individually. To facilitate scheduling, the clinical interview took place either several days prior to or several days following the psychophysiological assessment by separate research staff who were also naive to group membership.

Each participant completed a packet of questionnaire measures prior to the laboratory session. Electrodes for recording startle responses were attached and impedances checked. Prior to the picture presentation, the participant viewed a practice set of 10 neutral pictures and received nine startle probes in order to orient them to the procedure. The participant was then presented with pictures on a computer screen and acoustic startle probes were presented binaurally through headphones. Pictures were presented in three blocks of 21 pictures, with seven pictures of each valence included in each block. Pictures were presented in a fixed order, so that no more than two stimuli of a given valence (positive, negative, or neutral) were presented consecutively. Each picture was presented for 6 s with a mean intertrial interval of

14 s. The acoustic startle probes consisted of 95-dB white noise that was 50 ms in duration, with near-instantaneous rise and fall times. For each block, there were 19 startle probes delivered, at either 1.5 or 4.5 s following picture onset.

### 2.5. Data reduction and analysis

The EMG in response to the acoustic startle probes was reduced to eyeblink reflex magnitudes. Onset latency and magnitude of the largest peak between 20 and 120 ms following the startle probe was extracted using in-house software, which included a blink onset detection algorithm. Eyeblink responses were scored if they were characterized by a distinct rise (of at least twice the magnitude from the onset of the event) from baseline and return to baseline. All eyeblink responses were inspected by trained research staff in order to determine whether they were valid eyeblinks. Eyeblink reflex magnitudes were *z*-transformed within subjects due to large individual differences in the distribution of the measure. There were six trials per cell (probe time  $\times$  valence), and analyses were restricted to those subjects with at least three valid startle responses in each cell. Due to an insuffi-

cient number of startle responses and/or technical difficulties, data from three subjects were excluded. In order to improve the signal to noise ratio, the startle responses were averaged across both probe times.

To determine whether the affective modulation of startle occurred, an analysis of variance (ANOVA) was performed, with valence (negative, neutral, and positive) as the within-group factor, and startle response amplitude as the dependent variable. Following this, a mixed model ANOVA was conducted to determine whether there was any interaction between slide valence (positive, negative), slide content (social, nonsocial), and group (social anhedonia, control). All ANOVAs with a within-subjects factor used the Huynh and Feldt (1970) degrees of freedom correction in order to reduce the number of false positives. A probability value less than 0.05 was required for the results of a statistical test to be considered significant. Finally, in order to further investigate the nature of the affective deficit that characterizes social anhedonia, we compared the two groups in terms of their levels of trait anxiety, behavioral inhibition, behavioral activation, and trait affect. *T*-tests were conducted, using the two-tailed 0.05 level of significance.

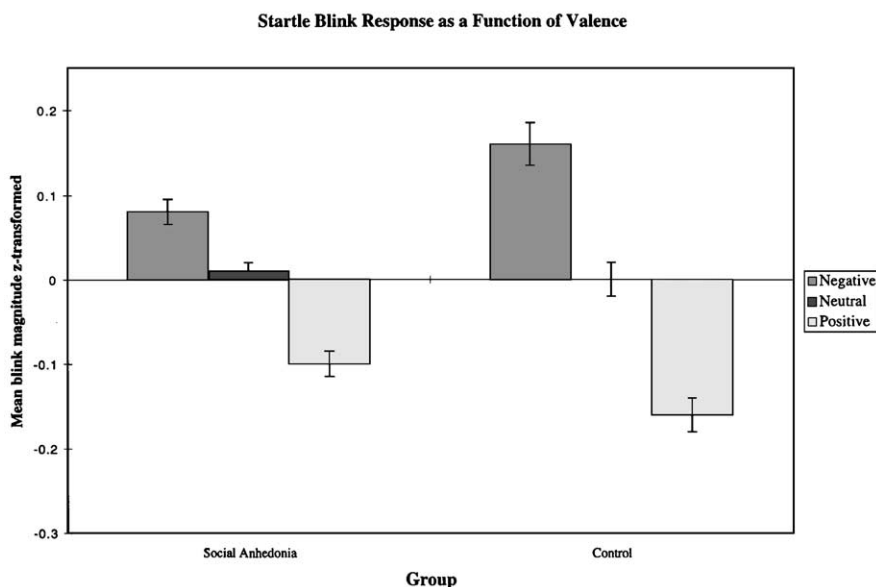


Fig. 1. Startle blink response as a function of valence for the social anhedonia and control groups.

### 3. Results

The two groups did not differ in terms of age,  $t(73)=0.10$ , n.s., or gender,  $\chi^2(1)=0.12$ , n.s. Similarly, the groups did not differ significantly in terms of their estimated Full Scale IQ,  $t(73)=-1.39$ , n.s.

#### 3.1. Affective modulation of the startle response

The startle reflex magnitudes elicited during positive, neutral, and negative slides for the control and social anhedonia group are shown in Fig. 1. There was a significant Valence effect,  $F(2, 146)=14.76$ ,  $p<0.001$ . The Valence  $\times$  Group interaction effect was not significant,  $F(2, 146)=1.11$ , n.s. Planned comparisons indicated that for both groups, relative to the neutral slides, the negative slides produced significantly larger responses ( $p<0.01$ ), and the positive slides produced significantly smaller responses ( $p<0.05$ ).

#### 3.2. Comparison of social vs. nonsocial picture sets

We compared the valence and arousal for the social and nonsocial picture sets for each gender, because the stimulus sets differed for males and females. For the

males, the negative slide sets differed in terms of mean valence ratings,  $t(19)=3.83$ ,  $p<0.01$ ; the nonsocial pictures, which consisted mostly of mutilated bodies, had more negative ratings than the social pictures, which mostly depicted group scenes of attack. However, the negative picture sets did not differ in terms of arousal ratings,  $t(19)=0.52$ , n.s. The males did not differ in terms of their ratings of valence or arousal for the social and nonsocial positive slide sets,  $t(19)=0.47$  and  $0.27$ , n.s., respectively.

For the females, the social and nonsocial negative slide sets did not differ in terms of either valence or arousal,  $t(19)=1.92$  and  $0.42$ , n.s., respectively. The social and nonsocial positive slide sets used for the female participants did not differ significantly in terms of valence ratings,  $t(19)=0.71$ , n.s., or in terms of arousal,  $t(19)=1.76$ , n.s.

#### 3.3. The effect of slide content

We were interested in determining whether the two groups would display differential response to the social–interpersonal pictures. The startle reflex magnitudes elicited during positive and negative slides with and without social–interpersonal content for the control and social anhedonia group are shown rela-

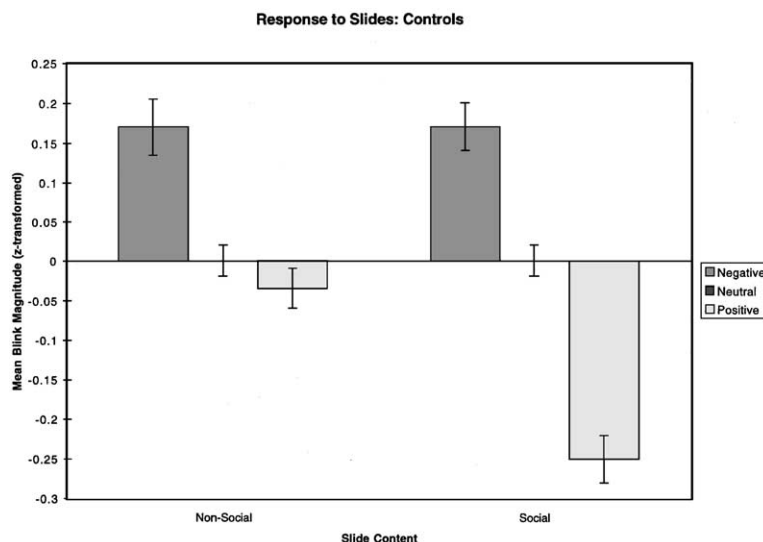


Fig. 2. The control group's startle blink response to nonsocial and social slides.

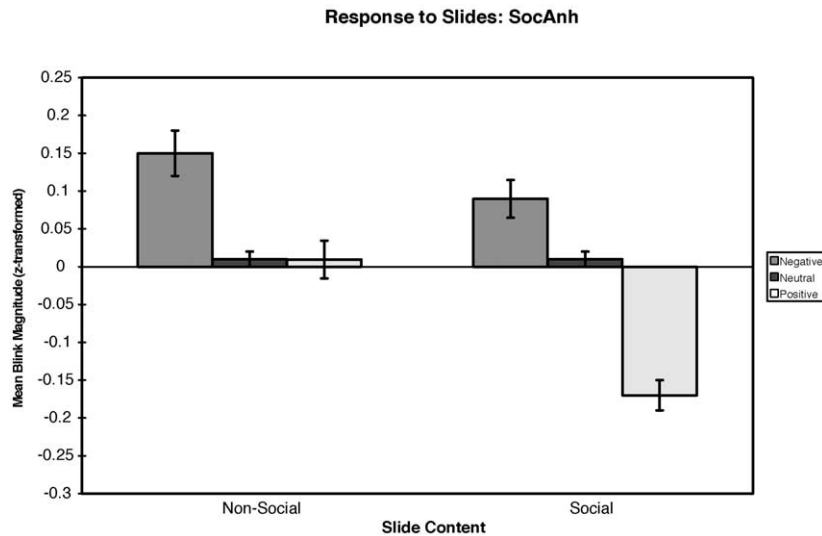


Fig. 3. The social anhedonia group's startle blink response to nonsocial and social slides.

tive to the startle magnitudes elicited in response to neutral slides in Figs. 2 and 3, respectively. A Group (social anhedonia, control)  $\times$  Valence (positive, negative)  $\times$  Content (social, nonsocial) ANOVA with startle response amplitude as the dependent variable indicated a main effect for Valence,  $F(1, 73)=23.91$ ,  $p<0.001$ . However, the groups did not differ significantly in terms of their affective modulation of the startle response,  $F(1, 73)=0.99$ , nor was there a significant Valence  $\times$  Group interaction effect,  $F(1,73)=1.12$ , n.s.

There was a significant Content effect,  $F(1, 73)=8.52$ ,  $p<0.01$ , though there was no significant Content  $\times$  Group interaction,  $F(1, 73)=0.05$ , n.s. We observed a significant Valence  $\times$  Content interaction,  $F(1, 73)=5.48$ ,  $p<0.05$ . There was no Valence  $\times$  Content  $\times$  Group interaction,  $F(1, 73)=0.39$ , n.s.

Further analyses pooling the subject groups indicated significantly greater blink attenuation for the positive slides containing social–interpersonal content relative to the positive slides without social–interpersonal content, paired-sample  $t(75)=3.72$ ,

Table 3  
Self-report questionnaire scores

Variable	Social anhedonia	Control	Test	<i>p</i>
PANAS PA	30.14 (5.80)	33.54 (4.78)	$t(73)=-2.78$	<0.01
PANAS NA	18.11 (5.00)	15.05 (2.93)	$t(56)=3.20$	<0.01
BAS Reward responsiveness	17.02 (1.99)	17.79 (1.38)	$t(73)=-1.95$	n.s.
BAS Drive	10.83 (2.61)	11.23 (1.99)	$t(73)=-0.74$	n.s.
BAS fun seeking	11.50 (2.57)	12.64 (1.80)	$t(62)=-2.21$	<0.05
BIS	21.92 (4.27)	21.03 (3.11)	$t(73)=1.04$	n.s.
APQ Social anxiety	15.28 (5.42)	13.56 (5.85)	$t(73)=1.31$	n.s.
APQ Physical anxiety	16.50 (5.64)	16.49 (6.86)	$t(73)=0.01$	n.s.
APQ Total	31.78 (9.71)	30.05 (10.88)	$t(73)=0.72$	n.s.

Means and standard deviations for self-report scales: PANAS PA = PANAS Positive Affect, PANAS NA = PANAS Negative Affect (Watson et al., 1988); BIS/BAS, Activities Preference Questionnaire. APQ = Activity Preference Questionnaire (Lykken, 1978); BIS = Behavioral Inhibition Scale; BAS = Behavioral Activation Scale (Carver and White, 1994).

$p < .001$ . Although content of the positive pictures affected the magnitude of the affective modulation of startle blink, the content of the negative pictures (i.e. pictures with vs. without social–interpersonal content) appeared to have no differential effect on the magnitude of the affective modulation, paired-sample  $t(75) = 0.43$ , n.s.

#### 3.4. Comparison of the two groups in terms of self-report measures of affect

Descriptive data for the self-report measures are presented in Table 3. The socially anhedonic group differed significantly from the control group in terms of their level of self-reported positive affect, self-reported negative affect, and fun/sensation seeking. We observed a trend, whereby the socially anhedonic group reported less reward responsiveness,  $t(73) = 1.95$ ,  $p = 0.055$ . The groups did not differ in terms of their self-reported drive scores, nor did they differ in terms of either social anxiety or physical anxiety, as assessed by the APQ.

## 4. Discussion

The current study used the affect startle paradigm in order to assess emotional reactivity in socially anhedonic individuals. Both the socially anhedonic individuals and the controls showed the typical emotional modulation of the startle reflex, namely, potentiated startle magnitude during viewing of negative valence pictures and attenuated startle magnitude during viewing of positive valence pictures.

This is the first study to date that has examined emotional reactivity in a socially anhedonic nonpatient sample. There are some similarities between the results based on the socially anhedonic individuals in the present sample and those based on schizophrenia samples in prior reports. The socially anhedonic undergraduates in the present study displayed normal emotion modulation of the startle blink reflex, paralleling the finding reported by Curtis et al. (1999) for their sample of schizophrenia patients. Interestingly, Schlenker et al. (1995) reported no difference in the startle response pattern between schizophrenia patients with vs. without high scores on an anhedonia questionnaire.

Another novel aspect of this investigation was our deliberate inclusion of positive stimuli that contained social–interpersonal content. We hypothesized that the socially anhedonic individuals would respond differently to positive slides than normally hedonic individuals, and that this difference would be greatest for the responses to positive slides containing social–interpersonal content. Our analyses did not support this hypothesis. However, we found that within the positively valenced picture sets, there was a significant effect of content. Across both groups, the positive pictures with social–interpersonal content produced greater magnitude startle attenuation than those without social–interpersonal content.

The work of Heller et al. (1997) suggests that during task engagement, arousal is associated with greater right hemisphere activation. Some individuals identified by elevated scores on the revised Social Anhedonia Scale fail to show the expected left spatial field perceptual bias in response to emotion chimera (Luh and Gooding, 1999). This atypical response to chimeric stimuli, which are differentially sensitive to right hemispheric engagement, suggests that the socially anhedonic individuals may have been less aroused by the affective content. Given these chimera findings, one would expect that, relative to the normally hedonic group, the social anhedonia group in the present study might experience the positive pictures, particularly those with social content, as less arousing. One limitation of the present investigation is that we did not obtain subjective ratings of slide arousal. However, we restricted our positive and negative slides to those associated with high arousal in prior investigations (c.f. Lang et al., 1993). Because we included only those positive and negative slides with high arousal ratings, even if there had been a difference in the groups' arousal ratings, this would not have influenced our main results.

If we had not observed normative affective modulation of startle in the socially anhedonic undergraduates, one possible explanation might be that the stimuli were insufficiently evocative. Use of laboratory-based stimuli, namely, the IAPS series, which depict social interactions rather than relying upon in vivo social interactions, may be a less robust way of eliciting emotion. However, these laboratory-based stimuli have been used with other samples, such

as anxious/phobic individuals, and indeed, have been demonstrated to elicit differential responses.

Socially anhedonic individuals may not be characterized by a global pleasure deficit. Klein (1987) has distinguished between appetitive pleasure and consummatory pleasure. According to Keltner and Kring (1998), anhedonia may reflect more of a deficit in approach or anticipatory pleasure rather than consummatory pleasure. The way in which we assessed affective modulation of the startle response, namely, by presenting our participants with positive visual stimuli, taps consummatory pleasure. The present data are consistent with the hypothesis, asserted by Kring (1999), that once in a pleasurable state, anhedonic individuals may derive as much pleasure as non-anhedonic individuals. It is possible that despite displaying normative involuntary response to the slides, the socially anhedonic individuals may have subjectively experienced the slides differently than the control group. That is, despite displaying the normative startle inhibition in response to positively valenced stimuli, individuals who score high on self-report measures of social anhedonia may in fact rate the positive slides as less pleasant; the potential disjunction between self-reported emotional experience and psychophysiological indices of emotional experience was not examined in the present study. Future investigation of startle modulation in an anticipatory pleasure context, i.e. using a cue to signal an appetitive stimulus reward, should be conducted in order to determine whether our finding of no significant differences between socially anhedonic individuals and normally hedonic individuals also extends to anticipatory pleasure.

We observed that our socially anhedonic group reported lower levels of positive affect and higher levels of negative affect relative to the controls. Similarly, Blanchard et al. (1998) noted that social anhedonia in schizophrenia was associated with low positive affect and high negative affect. Social anhedonia is a broad construct that characterizes various types of major mental illness. However, research (c.f. Horan and Blanchard, 1999) suggests that anhedonia may be a state characteristic of mood disorders, and a trait characteristic in some subtypes of schizophrenia. The revised social anhedonia scale is an imperfect indicator of risk for schizophrenia–spectrum disorders. Not all social anhedonics should be considered

schizotypes. Rather, we posit that individuals who report social anhedonia, low positive trait affect and high negative trait affect, and who also display psychophysiological response patterns similar to those observed in schizophrenic samples may be at heightened risk for the later development of schizophrenia. It is also important to recognize that our sample consists of high functioning college students. Given findings that individuals who do not attend college have lower functioning and are at greater risk for psychiatric disorders (Newman et al., 1998; Robins et al., 1984), our sample of social anhedonics may reflect the positive-outcome end of the continuum of individuals who self-report social anhedonia.

The nature of the affective deficits that characterize individuals reporting high levels of social anhedonia remains largely unexplored. The present study indicates that socially anhedonic individuals show a normal pattern of affective modulation of the startle reflex. The apparent inconsistency between their self-reports and startle magnitude suggests that the presumed affective deficit in social anhedonia is complex. The fact that socially anhedonic individuals differ from controls on several self-report measures, but not on startle, implies that the difference between groups is likely to be cortical rather than subcortical. Future studies are needed that directly measure cortical function in these groups. Previous indications that socially anhedonic individuals display atypical perceptual biases in response to emotion chimera (Luh and Gooding, 1999) are consistent with a cortical deficit and also suggest that the deficit associated with social anhedonia may lie more in emotional perception rather than emotional experience per se.

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