International Journal of Psychophysiology 115 (2017) 57–64

Contents lists available at ScienceDirect

International Journal of Psychophysiology

journal homepage: www.elsevier.com/locate/ijpsycho

Heritability of startle reactivity and affect modified startle

Devika Dhamija [a,*], Catherine Tuvblad [a,b], Michael E. Dawson [a], Adrian Raine [c], Laura A. Baker [a]

[a] Department of Psychology, University of Southern California, USA
[b] School of Psychology, Law and Social Work, Örebro University, Sweden
[c] Departments of Criminology, Psychiatry, and Psychology, University of Pennsylvania, USA

ARTICLE INFO

Article history:
Received 3 August 2015
Received in revised form 16 August 2016
Accepted 15 September 2016
Available online 22 September 2016

Keywords:
Startle blink reflex
Heritability
Genetic
Environmental, affect modification

ABSTRACT

Startle reflex and affect-modified startle reflex are used as indicators of defensive reactivity and emotional processing, respectively. The present study investigated the heritability of both the startle blink reflex and affect modification of this reflex in a community sample of 772 twins ages 14–15 years old. Subjects were shown affective picture slides falling in three valence categories: negative, positive and neutral; crossed with two arousal categories: high arousal and low arousal. Some of these slides were accompanied with a loud startling noise. Results suggested sex differences in mean levels of startle reflex as well as in proportions of variance explained by genetic and environmental factors. Females had higher mean startle blink amplitudes for each valence-arousal slide category, indicating greater baseline defensive reactivity compared to males. Startle blink reflex in males was significantly heritable (49%), whereas in females, variance was explained primarily by shared environmental factors (53%) and non-shared environmental factors (41%). Heritability of affect modified startle (AMS) was found to be negligible in both males and females. These results suggest sex differences in the etiology of startle reactivity, while questioning the utility of the startle paradigm for understanding the genetic basis of emotional processing.

1. Introduction

Startle blink reflex is a defensive withdrawal reflex to a startling stimulus and is thought to be an early component of a whole-body response, which serves a protective function. Startle blink reflex has been shown to be modified by attention and arousal as well as affect (for reviews, see Dawson et al., 1999; Filion et al., 1998; Lang et al., 1990). According to the motivational priming theory for modification of startle reflex by affect (Lang et al., 1990), emotions can be viewed as motivational states or "action dispositions" which can interact with, and modify unconditioned responses, including startle reflex. Two opposing motivational states; appetitive and aversive; are thought to underlie these action dispositions. Whereas appetitive responses favor approach, aversive responses underlie defensive, avoidant behavior. It has been demonstrated that an individual in a current aversive state exhibits a greater unconditioned defensive response than in a neutral state; and an inhibited unconditioned defensive response in an appetitive state (Lang et al., 1990; Vrana and Lang, 1990).

Previous studies have shown that when subjects are presented an acoustic startle stimulus during positive, negative or neutral valence pictures, the startle eye blink reflex is reliably potentiated while viewing the negative valence pictures and inhibited while viewing positive valence pictures (Vrana et al., 1988). The foreground affective state of an individual could thus "prime" and modify the characteristics of this reflex, a defensive response, in an individual. This affective modification of startle reflex has since been replicated in many studies and has been utilized to discriminate the reactivity to different emotional stimuli (Grillon and Baas, 2003). Research has shown that the ability of startle blink reflex to distinguish between different affective states of an individual is a very reliable and stable effect, even after accounting for habituation in response over time (Bradley et al., 1990; Bradley et al., 1993; Vrana et al., 1988).

General reactivity to startle probes and its affective modification are associated with disorders involving emotional processing deficits (Cook III, 1999). For example, it has been shown that the potentiation of startle blink reflex during an aversive state is absent in psychopaths (Patrick et al., 1993). The overall startle magnitude did not differ across psychopathic and non-psychopathic groups and only the modification in response to aversive stimuli was absent in psychopaths, indicating decreased affective responding only to negative stimuli and not to the startling stimulus itself. Absence of startle potentiation is specifically related to the interpersonal factor of psychopathy (Benning et al., 2005). Affect-modified startle (AMS) has also been studied in reference to mood-related disorders. For example, in depressed (Kaviani et al., 2004) and anxious patients (Cuthbert et al., 2003; Waters et al., 2008), deviated patterns of AMS have been found. Atypical patterns in reactivity and AMS have also been seen for patients with both borderline personality disorder (Ebner-Priemer et al., 2005; Hazlett et al., 2007) and

* Corresponding author at: University of Southern California (USC), 3620 S. McClintock Ave, Department of Psychology (SGM 501), Los Angeles, CA 90089-1061, USA.
E-mail address: ddhamija@usc.edu (D. Dhamija).

http://dx.doi.org/10.1016/j.ijpsycho.2016.09.009
0167-8760/

bipolar disorder (Giakoumaki et al., 2010), with elevated startle reactivity and modification to negative valence stimuli seen in patients with borderline perosnality disorder and blunted startle reactivity in patients with bipolar disorder. The results suggest that both startle reactivity (startle amplitude) and AMS show deviated patterns in disorders with dysregulated emotional processing.

Abnormal startle patterns also appear to run in families of patients with emotion related mental disorders. Healthy siblings of bipolar patients have blunted baseline startle responses as well as AMS (Giakoumaki et al., 2010). Subjects with a family history of alcoholism also tend to have blunted AMS and do not show startle potentiation to negative foreground information (Miranda et al., 2002). It is unclear; however, to what extent these family based associations may be due to genetic or shared environmental effects.

Few previous studies have examined the heritability of startle reactivity and AMS. One study examined the correlations between monozygotic (MZ) and dizygotic (DZ) twins for mean startle amplitudes and AMS (Carlson et al., 1997) and found that MZ twins had higher correlations on both measures when compared to DZ twins, suggesting that both startle reactivity and AMS may be under genetic control. Two other larger studies, however, found that although reactivity to a startling probe showed significant heritability, AMS did not (Anokhin et al., 2007; Vaidyanathan et al., 2014). The aforementioned studies have not examined sex differences in the heritability of startle or AMS. It has been previously shown that females tend to rate negative-valence pictures as more unpleasant than males and have greater defensive reactivity to negatively-valence pictures, as measured by a number of autonomic responses (Bradley et al., 2001). In studies of pre-pulse inhibition, females display lesser inhibition in comparison to males (Kumari et al., 2003; Swerdlow et al., 1993) and this effect has also shown to be sensitive to the menstrual phase (Kumari et al., 2010). Considering the notable differences in defensive reactivity and sensorimotor gating between males and females, it is plausible that the relative contributions of genetic and environmental influences to startle reactivity and AMS also differ between the two sexes.

The present study aimed to bridge this gap in the literature by (1) examining to what extent genetic and environmental factors influence both startle reactivity and affective modification in a community-based twin sample, using an affect modified startle paradigm; and (2) investigating potential sex differences in the genetic and environmental influences in these constructs. Startle reactivity was operationalized as the magnitude of the startle eyeblink response and AMS was defined as the percent change of the response to valence pictures compared to neutral pictures.

2. Methods

2.1. Participants

The data utilized in this study were collected as a part of the University of Southern California (USC) Twin Study of Risk Factors for Antisocial Behavior (RFAB). RFAB is an ongoing longitudinal study aimed at assessing the biological and social risk factors for antisocial behavior and their gene-environment interplay. The sample is ethnically and socioeconomically representative of the greater Los Angeles area. To date, four waves of data have been collected and the study is currently in its fifth wave of collection. Wave1 data were collected when the twins were 9–10 years old (*mean age* = 9.60, *SD* = 0.59, *N* = 614 twin pairs), at Wave 2, the twins were 11–13 years old (*mean age* = 11.79, *SD* = 0.92, *N* = 445 twin pairs), at Wave 3, the twins were 14–15 years old (*mean age* = 14.87, *SD* = 0.87, *N* = 604 twin pairs) and at Wave 4 the twins were 16–18 years old (*mean age* = 17.28, *SD* = 0.77, *N* = 504 twin pairs) (Baker et al., 2013).

In the present study, data from the third wave were evaluated, i.e., when the twins were 14–15 years old. Of the total sample, 772 participants completed the startle task, of which 370 were males and 402 were females. The resulting sample consisted of 154 MZ males, 125 DZ males, 172 MZ females, 137 DZ females and 184 opposite sex DZ twins. Zygosity was determined through DNA microsatellite analysis (7 concordant and zero discordant markers for MZ; one or more discordant markers for DZ) for 87% of the same-sex twin pairs. For the remaining same-sex twin pairs, zygosity was established by questionnaire items about the twins' physical similarity and the frequency with which people confuse them. The questionnaire was used only when DNA samples were insufficient for one or both twins in a pair. When both questionnaire and DNA results were available, there was a 90% agreement between the two (Baker et al., 2006, 2013).

2.2. Procedure

Subjects participated in a ~5-hour laboratory testing session, which was divided into two parts: a 3-hour neuropsychological testing and behavioral assessment and a 2-hour psychophysiological assessment. The startle task was conducted during psychophysiological assessment of the twins.

2.3. Startle task

The startle task was conducted in a testing room exclusively assigned for psychophysiological testing. The picture stimuli consisted of 30 IAPS (International Affective Picture System; Lang et al., 1999) slides falling in five different categories based on the normative valence and arousal ratings: low arousal neutral, low arousal negative, high arousal negative and low arousal positive and high arousal positive pictures. The average published valence and arousal ratings on a 1–9 scale for each of these categories are: low arousal neutral - 4.93 and 2.48; low arousal negative - 1.96 and 5.81; high arousal negative - 2.82 and 6.62; low arousal positive - 8.13 and 4.63 and high arousal positive - 7.68 and 6.37. The pictures were presented in 6 blocks and each block consisted of five pictures; one picture from each arousal-valence category. The order of slides was fixed across all subjects. Each picture was presented for 6 s with a variable inter-trial interval (ITI) of 4–10 s. During the ITIs, a fixation cross appeared on the screen in front of the subject. Startle probes, bursts of loud white noise (105 dB), were delivered through earphones on three out of six trials for each arousal-valence category as well as during five ITI trials. Thus, a total of 20 startle probes were delivered throughout the task. Startle probes were presented either 3.5, 4.5 or 5.5 s after the picture onset.

2.4. EMG recordings

Electromyographic activity was recorded using two 4 mm Ag/AgCl electrodes placed 1 cm apart, spaced about 1 cm below the outer canthi of the eye after the area had been cleaned using NuPrep gel. Data were collected using hardware and software from the James Long Company (1999; Caroga Lake, New York) at a sampling rate of 512 Hz. The baseline window was 70 ms which lasted from 50 ms before and 20 ms after each probe. The startle response window was set to 20–200 ms post-onset of each startle stimulus and the peak amplitude in this window was recorded. Trials in which the baseline was two standard deviations above the moving average baseline for a subject, were eliminated to avoid any confounding, noisy measurements.

Any value 3 standard deviations above or below a subjects mean startle across all trials was removed. Moreover, boxplots were plotted for each startle response and extreme outlier data points, i.e., greater or lesser than 3 times the inter-quartile range from the first or third quartile (usually appearing at the higher end of the distribution) were removed. This two- step approach was used because outliers in the data could be based on both within-individual values as well as values for a specific trial. <2% of the sample was missing more than one trial in each of the valence-arousal categories. The percentage of participants having all three trials, for each valence-arousal category, ranged from 80