Biological Psychology 107 (2015) 44–51

Contents lists available at ScienceDirect

Biological Psychology

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

Diminished P300 to physical risk in sensation seeking

Ya Zheng[a], Fei Tan[a], Jing Xu[b,*], Yi Chang[b], Yuanyuan Zhang[c], Huijuan Shen[a]

[a] Department of Psychology, Dalian Medical University, Dalian 116044, China
[b] Department of Neurology and Psychiatry, First Affiliated Hospital, Dalian Medical University, Dalian 116011, China
[c] School of Public Health, Dalian Medical University, Dalian 116044, China

ARTICLE INFO

Article history:
Received 1 October 2014
Accepted 2 March 2015
Available online 9 March 2015

Keywords:
Sensation seeking
Emotional arousal
Event-related potentials
P300

ABSTRACT

Zuckerman's theory proposes individual differences in optimal arousal and arousability level as the root of the sensation-seeking trait. The current study addressed how sensation seeking influences responses to emotional arousal at the electrophysiological level during a passive viewing task and at the psychometrical level during a self-assessment task. Electrophysiologically, high sensation seekers (HSSs) compared to low sensation seekers (LSSs) exhibited a reduced P300 for high-arousing stimuli (adventure and surreal pictures), but not for low-arousing stimuli (leisure and neutral pictures). Psychometrically, HSSs displayed a higher preference for adventure and surreal pictures whereas LSSs showed a higher preference for leisure pictures. Instead of supporting the optimal arousal hypothesis, these findings suggest that sensation seeking is associated with diminished P300 to physical risk, which may be driven by a hypoactive avoidance system in sensation seeking.

1. Introduction

As a personality trait characterized by a strong desire for varied, novel, complex, and intense stimulation and a willingness to take risks for such experience (Zuckerman, 1994), sensation seeking has been viewed as a potential endophenotype of various risk-taking behaviors (Benjamin, Ebstein, & Belmaker, 2001; Gottesman & Gould, 2003). High sensation seekers (HSSs), as compared to low sensation seekers (LSSs), are more likely to engage in reckless driving (Jonah, 1997), physical risk sports (Ruedl, Abart, Ledochowski, Burtscher, & Kopp, 2012), substance abuse (Bardo et al., 2007), excessive gambling (Harris, Newby, & Klein, 2013), risky sexual activities (Hoyle, Fejfar, & Miller, 2000), aggressive and unsocialized behaviors (Wilson & Scarpa, 2011), and even suicide behavior (Ortin, Lake, Kleinman, & Gould, 2012).

Behavioral differences between HSSs and LSSs may be attributed to an underlying dimension of arousal. The arousal concept was first proposed by Eysenck and aligned with his theory of extraversion (Eysenck, 1967). Eysenck asserted that extroverts have a higher optimal level of stimulation or arousal than introverts, as evidenced by the fact of a reduced sensitivity to physical stimulation in extroverts compared to introverts (De Pascalis, 2004; Matthews & Gilliland, 1999). Similarly, Zuckerman (1969) postulated that HSSs, as compared to LSSs, are below an optimal level of arousal and thus need more novel and intense forms of sensation to reach and maintain a higher optimal level of arousal. Such a view affords the hypothesis of lower tonic or phasic arousal levels or both in HSSs compared to LSSs, which however, in contrast to the extraversion theory, has received little empirical support. Later, Zuckerman (1984) emphasized the sensation-seeking theory based on an optimal level of catecholamine system activity such that HSSs relative to LSSs have more excitable autonomic nervous systems and central nervous systems. In support of this hypothesis, numerous studies have found that HSSs exhibit increased event-related potential responses as a function of increasing intensity of sensory stimulus, whereas LSSs display an opposite pattern (Brocke, Beauducel, John, Debener, & Heilemann, 2000; Hegerl, Gallinat, & Mrowinski, 1995; Zuckerman, Murtaugh, & Siegel, 1974).

Given that emotional stimuli provide a reliable source of arousal, it is of importance to investigate emotional arousal in sensation seeking. Ample research has demonstrated a close relationship between sensation seeking and emotional activity. At the psychometrical level, HSSs compared to LSSs show a stronger preference for negative stimuli (Rawlings, 2003; Zaleski, 1984) and lower sensitivity to disgust video (Dvorak, Simons, & Wray, 2011). At the autonomic level, HSSs give greater skin conductance responses to violent and sexual stimuli compared to LSSs (Smith, Davidson, Perlstein, & Gonzalez, 1990; Smith, Davidson, Smith, Goldstein, & Perlstein, 1989; Smith, Perlstein, Davidson, & Michael, 1986). However, HSSs versus LSSs exhibit no startle potentiation in the face of threatening stimuli (Lissek & Powers, 2003) and weaker fear-potentiated startle during the anticipation of aversive stimuli

* Corresponding author. Tel.: +86 411 83635963x7257.
E-mail address: xujing_doc@aliyun.com (J. Xu).

http://dx.doi.org/10.1016/j.biopsycho.2015.03.003
0301-0511/

(Lissek et al., 2005). At the neural level, HSSs show greater activation to emotionally arousing stimuli in the right insula and posterior medial orbitofrontal cortex, whereas LSSs exhibit greater activation in the anterior medial orbitofrontal cortex and anterior cingulate (Joseph, Liu, Jiang, Lynam, & Kelly, 2009). However, sensation seeking is negatively correlated with brain activation in the thalamus and insula to neutral movie clips, but not to threat clips (Straube et al., 2010). Additionally, HSSs compared to LSSs display a reduced N2 component but an enhanced P300 component in the frontal areas for emotional stimuli (Zheng et al., 2011).

A limitation of previous research is that most have focused on the dimension of emotional valence. On the contrary, there is a surprising scarceness of research addressing the relationship between emotional arousal and sensation seeking systematically. It is well-known that all emotional events are rooted in motivational states and can be organized by the defensive motivational system (linked to negative affect) and the appetitive motivational system (linked to positive affect). As another dominant dimension of emotion, arousal reflects the intensity that is mobilized by either motivational system (Lang, Bradley, & Cuthbert, 1997). A multitude of research has demonstrated that whereas the behavioral activation system (BAS) is associated with the positive-approach emotion, the behavioral inhibition system (BIS) is associated with the negative-avoidance emotion (Balconi, Falbo, & Conte, 2012; Pascalis, Strippoli, Riccardi, & Vergari, 2004; De Pascalis, Varriale, & D'Antuono, 2010; Simon et al., 2010). As a BAS-related dimension, sensation seeking would be theoretically related to enhanced sensitivity and responsiveness to stimuli with positive valence. Therefore, the present study aimed to address systematically the issue between sensation seeking and emotionally positive arousal.

Event-related potential (ERP) technique provides unique insights into the neural dynamics of emotional processing (e.g., emotional valence and arousal), from the early attention allocation to the late cognitive appraisal (Hajcak, Weinberg, MacNamara, & Foti, 2012; Olofsson, Nordin, Sequeira, & Polich, 2008). Although early ERP components (e.g., <300 ms) can be modulated by emotional arousal (both pleasant and unpleasant vs. neutral stimuli), a number of studies have demonstrated that emotional arousal primarily influences relatively late ERP components (e.g., >300 ms); that is, the P300 and late positive potential (LPP). The P300 is a parietally maximal positive deflection that peaks between 300 and 400 ms post stimulus onset (Sutton, Braren, Zubin, & John, 1965). Following the P300, the LPP is a slow, sustained positivity with a centroparietal distribution beginning around 400 ms (Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000). Despite the similar onset latency of the P300 and LPP, there is emerging evidence that the P300 reflects the initial allocation of attentional resources based on motivational significance, whereas the LPP indexes more elaborated processing related to stimulus significance (Hajcak et al., 2012; Schupp, Flaisch, Stockburger, & Junghofer, 2006). For instance, the LPP, unlike the P300, is uniquely associated with memory encoding and storage (Dolcos & Cabeza, 2002), cognitive reappraisal (Hajcak & Nieuwenhuis, 2006), and behavioral interference (Weinberg & Hajcak, 2011).

The present study was to investigate the relationship between sensation seeking and emotional stimuli varying along the arousal dimension at the electrophysiological level and the psychometrical level. Because sensation seeking would be theoretically related to enhanced sensitivity to stimuli with positive valence, we employed positive stimuli of varying arousal (low, medium, and high) with neutral stimuli serving as the baseline condition. Moreover, because stimulus relevance is one of the important factors to maximize sensation-seeking group differences (Smith et al., 1990, 1989, 1986), we employed the stimuli presumably associated with the sensation-seeking trait. During the ERP task, HSSs and LSSs passively viewed neutral pictures and positive pictures of varying arousal. Later, they rated each picture on the level of valence, arousal, and approach/avoidance tendency in a self-assessment task. We predicted that both the P300 and LPP would increase as a function of arousal level. Based on the previous observation of more excitable central nervous systems for HSSs, we predicted that psychometrically HSSs would display a greater preference for high-arousing pictures whereas LSSs would exhibit a higher preference for low-arousing pictures. Importantly, the ERP arousal effect would be modulated by sensation seeking such that HSSs compared to LSSs would display an enhanced P300 and LPP, especially for the high-arousing pictures.

2. Methods

2.1. Participants

Participants were recruited on the basis of their scores on the Chinese version of the Sensation Seeking Scale Form V (SSS-V; Wang et al., 2000; Zuckerman, Eysenck, & Eysenck, 1978). The SSS-V was administered initially in a large sample ($N = 250$, 162 females and 88 males) in introductory psychology courses at the Dalian Medical University (Fall 2013). Responders in the top quartile of the distribution were assigned to high sensation-seeking group whereas those in the bottom quartile to low sensation-seeking group. Given the gender imbalance in the sample, the selection criterion was applied separately to the males and females. Additional recruitment criteria included: (1) aged 18–25 years, (2) normal or correct-to-normal visual acuity, (3) right-handed as determined by self-report, (4) no current substance use, (5) free from any neurological or psychological disorders. Thus, the final sample was composed of 16 HSSs (8 females and 8 males) and 16 LSSs (8 females and 8 males). As expected, HSSs and LSSs differed significantly on the overall sensation-seeking score ($p < .0001$) but did not differ by age, gender, and educational level ($ps > .5$; Table 1). This study was approved by a local ethical committee in accordance with the 1964 Declaration of Helsinki. Informed consent was obtained from each participant before the experiment.

2.2. Stimuli

The stimulus selection consisted of three steps. First, a preliminary collection was performed from the International Affective Picture System (Lang, Bradley, & Cuthbert, 2005), the Chinese Affective Picture System (Bai, Ma, Huang, & Luo, 2005), and other various sources on the Internet, resulting in a total of 1670 pictures (408 adventure, 544 surreal, 512 leisure, and 206 neutral pictures). As specific picture content appears to affect the electrophysiological activity (Briggs & Martin, 2009; Weinberg & Hajcak, 2010), the adventure, surreal, and leisure pictures were carefully selected on the basis of the items in the SSS-V to keep the content of each category homogeneous. The adventure pictures depicted people's adventure activities such as parachuting, base jumping, and

Table 1
Sample characteristics and accepted ERP trials (M ± SD).

	HSSs ($N = 16$)	LSSs ($N = 16$)
Gender (M/F)	8/8	8/8
Age (years)	22.94 ± 1.06	22.50 ± .63
Sensation seeking score	26.56 ± 4.05	7.44 ± 1.37
Accepted ERP trials		
Adventure	47 ± 2.34	46 ± 2.63
Surreal	46 ± 2.38	46 ± 3.10
Leisure	45 ± 3.08	47 ± 2.75
Neutral	46 ± 2.62	46 ± 3.31

Note: HSSs, high sensation seekers; LSSs, low sensation seekers.