International Journal of Psychophysiology 88 (2013) 213–217

Contents lists available at SciVerse ScienceDirect

International Journal of Psychophysiology

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

A pilot study on changes of cardiac vagal tone in individuals with low trait positive affect: The effect of positive psychotherapy ☆

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ARTICLE INFO

Article history:
Received 11 October 2012
Received in revised form 15 April 2013
Accepted 17 April 2013
Available online 23 April 2013

Keywords:
Respiratory sinus arrhythmia
Trait positive affect
Positive psychotherapy

ABSTRACT

The association between changes of trait affect and changes of vagal tone was investigated in the present study. Basal physiological data were collected from 70 college students of high ($n = 33$) and low trait positive affect ($n = 37$) (HPA vs. LPA) groups selected by Positive and Negative Affect Schedule (PANAS). Then the final LPA participants ($n = 34$) were randomly assigned to either a four month Positive Psychotherapy (PPT) group ($n = 16$) or a control group ($n = 18$), and their basal physiological and PANAS data were collected immediately after the treatment. The study results showed that compared to the LPA group, the HPA group had higher basal respiratory sinus arrhythmia (RSA). Compared to the control group, the PPT group had changes in trait affect and basal RSA, and increases in trait PA were associated with increases in basal RSA independently of decreases in trait NA. These findings suggest that basal vagal tone of individuals with low trait PA might be improved by increasing their trait PA.

1. Introduction

A growing body of literature has shown that positive affect (PA) is related to health outcomes. High levels of PA are found to be associated with better concurrent and future health prospects, and the influence of PA on health is independent of negative affect (NA) and other disease risk factors (Chida and Steptoe, 2008; Dockray and Steptoe, 2010; Pressman and Cohen, 2005; Steptoe et al., 2009). Accumulating studies have indicated some specific biological processes that may mediate the association between PA and health, including neuroendocrine, autonomic and immune systems (Chida and Steptoe, 2008; Dockray and Steptoe, 2010; Pressman and Cohen, 2005; Steptoe et al., 2009). Of these studies, Pressman and Cohen (2005) proposed that trait PA might maintain homeostasis to benefit health through autonomic nervous system regulation, such as dampening sympathetic nervous system activity and activating parasympathetic nervous system activity.

Cardiac vagal tone, an index of the functional status of the parasympathetic nervous system, reflects the vagal influences on heart rate variability at the rate of respiration (i.e., respiratory sinus arrhythmia [RSA]) (Berntson et al., 1997; Grossman and Taylor, 2007). At a basic level, high vagal tone (basal RSA) reflects the organism's ability to maintain homeostasis and its capacity to adaptively react to the environment (Porges, 2003, 2007). It is therefore indicative of physiological flexibility and is found to be related to decreased rates of physical illness (Porges, 1992; Thayer and Lane, 2007; Thayer and Sternberg, 2006). Emerging evidence suggests that PA is associated with basal vagal tone. For example, Oveis et al. (2009) examined the association between basal vagal tone and positive emotionality (extraversion, agreeableness, positive mood and optimism) and found that basal vagal tone was stably associated with trait PA (positive mood). Wang et al. (2013) also found that basal vagal tone was stably associated with trait PA. These findings implicate that there is a close relationship between trait PA and basal vagal tone, and the higher trait PA individuals have, the higher their basal vagal tone. Thus, if the trait PA levels of individuals with low trait PA could be enhanced, it is possible that their basal vagal tone levels would be increased as well. Recently, a study examined the association between changes of state PA and changes of basal vagal tone and showed that basal vagal tone prospectively predicted increases in positive emotions over the span of nine weeks and, reciprocally, that these increases in positive emotions prospectively predicted increases in vagal tone (Kok and Fredrickson, 2010). However, whether trait PA levels can be changed and whether increases of trait PA are related to increases of basal vagal tone still remains an open question.

Intervention studies that focused on alleviation of negative emotionality such as depression and panic disorder by cognitive behavioral treatment (CBT) have found that decreases of negative emotionality corresponded to simultaneously increases in cardiac vagal tone (Carney et al., 2000; Chambers and Allen, 2002; Garakani et al., 2009). These findings suggest that trait-like emotionality and basal vagal tone might be changed by psychotherapy. Inspired by these studies, the present study will adopt Positive Psychotherapy (PPT) to examine whether trait

☆ This research was supported by the National Science Foundation Grant (30970912) awarded to Zhenhong Wang, and the Innovation Funds of Graduate Programs of Shaanxi Normal University (2011CXB001) awarded to Wei Lü.

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http://dx.doi.org/10.1016/j.ijpsycho.2013.04.012

PA can be changed, and whether changes of trait PA are associated with changes of basal vagal tone. PPT, drawn from positive psychology, is a successive treatment technique in raising PA (Seligman et al., 2006, 2005). Compared to other treatments, such as CBT, PPT not only focuses on effectively reducing negative symptoms, but also directly and primarily builds positive emotions, engagement, and meaning (Froh et al., 2009; Seligman et al., 2006). Thus, the present study aims to conduct PPT on individuals with low trait PA to examine whether their trait PA would increase, and whether increases in trait PA would be associated with improvement of basal vagal tone.

Overall, the present study hypotheses are as follows: (1) high trait positive affect (HPA) group would have higher basal RSA than low trait positive affect (LPA) group. (2) Compared to the control group, the trait PA levels of LPA participants who receive PPT would be significantly enhanced, and increases in trait PA would be associated with increases in basal RSA.

2. Methods

2.1. Participants

The Chinese trait version of PANAS was administered to 220 healthy college students in the educational psychology class. Of these students, 70 participants (47 female; $M_{age} = 20.0$ years, $SD = 4.28$) were eligible. Those who scored 1 standard deviation (SD) above the mean on the Chinese trait version of Positive Affect Schedule were high trait positive affect group (HPA, $n = 33$), whereas those who scored 1 standard deviation (SD) below the mean were low trait positive affect group (LPA, $n = 37$). The total 70 participants took part in a laboratory physiology test during in the initial lab visit. After that, LPA participants were randomly assigned to either a Positive Psychotherapy (PPT) group ($n = 19$) or a no-treatment control group ($n = 18$). During the four month (16 sessions) intervention, 1 person dropped-out of the study, and 2 persons were excluded for incompletely taking part in the treatment. Thus, the final data were collected at pre- and post-treatment for a total of 34 participants (16 participants of the PPT group and 18 participants of the control group).

2.2. Measures

2.2.1. Positive and negative affect schedule

Positive and negative affects were assessed using the Chinese revised edition of the trait version of the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988; Huang et al., 2003). The scale consists of 10 items for trait NA (afraid, ashamed, distressed, guilty, hostile, irritable, jittery, nervous, scared, and upset) and 10 items for trait PA (active, alert, attentive, determined, enthusiastic, excited, inspired, interested, proud, and strong). Ratings were made on a 5-point scale, ranging from 1 (very slightly or not at all) to 5 (extremely). Participants were asked to indicate the extent to which each item was characteristic of their dispositional affect. The factor loading of items on the subscale of trait PA ranged from 0.40 to 0.76, and the factor loading of items on the subscale of trait NA ranged from 0.45 to 0.75 (Huang et al., 2003). Cronbach's alphas of the trait PA and the trait NA were 0.85 and 0.83, respectively.

2.2.2. Respiratory sinus arrhythmia (RSA)

Respiratory sinus arrhythmia (RSA) is a noninvasive means of observing vagal (parasympathetic) activity, and is assessed by examining the degree of respiration-linked variability in the heart rate (Berntson et al., 1997; Grossman and Taylor, 2007). To assess RSA, electrocardiography (ECG) and respiration data were recorded by an integrated system and software package (Biopac MP150, AcqKnowledge; Biopac System Inc., 42 Aero Camino, Goleta, California, 93117, USA). The ECG data were amplified using a Biopac ECG100 electrocardiogram amplifier and collected from participants using 3 Ag-AgCI disposable electrodes placed in the standard lead II configuration. The Biopac ECG100C amplifier used a band-pass filter of 35 Hz and 0.5 Hz, sampling at 1000 Hz. Respiration was amplified using a Biopac RSP100C amplifier and was recorded using TSD201 transducers embedded in a respiratory belt around the participant's chest (at the level of the fifth thoracic vertebrae). The Biopac RSP100C amplifier used a band-pass filter of 1 Hz and 0.5 Hz. The ECG and respiration data were measured continuously during the experimental session, and for each participant, the physiological data were ensemble averaged for each minute.

RSA was estimated using a high frequency of heart rate variability, which was analyzed by Acqknowledge 4.1 Software. The raw ECG data were first inspected using template matching function and then visually inspected to delete artifacts and abnormal beats. The time series of identified R-wave were converted to interbeat intervals (IBIs) and sampled at 4 Hz (with interpolation) to produce equal time intervals. The prorated IBI data were then linearly detrended, end tapered, and submitted to a fast Fourier transformation according to procedures outlined by Berntson et al. (1997). RSA was quantified via a high frequency of the IBI's power spectrum corresponding to the respiratory cycle (0.15–0.40 Hz; Berntson et al., 1997). High-frequency power values were transformed via a natural logarithm to normalize the distribution yielding unit of $\ln(ms^2)$. In the present study, respiration was recorded in order to detect whether the participants breathe stably during 5 min baseline ECG data collection. The raw data were checked and all participants' respirations were found to be eligible.

2.3. Procedure

All total 70 participants of both HPA and LPA group were asked to sleep well the night before the study and refrain from taking any drugs (including caffeine and nicotine) for 2 h prior to the study. This step was performed to rule out any exogenous effects on the physiological measures. During the initial visit, participants provided informed consent. Then, the ECG recording electrodes and respiratory belts were attached. Participants were given 10 min to acclimate to the laboratory while seated in a comfortable chair facing a computer monitor. After that, the basal physiological data collection procedure began. The first instructions, given on the monitor screen, were "Welcome to our study. Please look at the following picture, and remain relaxed and quiet while breathing normally." Next, a neutral picture (a cup) was presented (the neutral picture was selected from the International Affective Picture System, IAPS, Lang et al., 2005) for 5 min. This time served as the basal period, during which ECG and respiration were continuously measured while the participant looked at the picture. After the initial lab visit, the LPA participants ($n = 34$) were given a thorough description of the following study and were asked to give written consent. Then they were randomly assigned to either a PPT group ($n = 16$) or a control group ($n = 18$), and following completion of treatment four months later, both PPT and control groups returned to the lab to complete the Chinese trait version of PANAS and to receive another 5 min basal ECG and respiratory data collection.

2.4. The Positive Psychotherapy (PPT) protocol

Based on the framework of the Positive Psychotherapy (PPT) protocol designed by Seligman and his colleagues (Seligman, 2002; Seligman et al., 2005, 2006), we designed a 16-week, two hours per week group PPT, which we administered to two groups (8 participants in each group). Each group was led by a clinical psychology postdoctoral fellow of our university. Different from the original PPT protocol designed by Seligman et al. (2006), the exercise requiring participants to write an obituary was excluded in the present study, because words or sentences that related to "death" were the taboo in the Chinese culture. Thus, five exercises were included in our intervention program, with the following fixed order: three good things, strengths, savoring, gratitude visit and