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TRAIT ANXIETY MODERATES THE EFFECT OF DENTAL SURGERY PHASES ON VAGAL ACTIVATION

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Decreases in parasympathetic (PNS) activation are a normative reaction to stressful situations. By the Porges' Polyvagal theory (Porges, 1995) and Thayer and Lane's (2000) model of neurovisceral integration, PNS inflexibility is related to poorer functioning of emotional and other psychological regulatory mechanisms. The aim of the present study was to investigate the differences in PNS activation between high and low trait anxiety individuals throughout two phases of dental surgery - the period of waiting for the beginning of the surgery and the phase after the injection of anesthesia which was expected to be more stressful. PNS activation defined as high frequency heart rate variability was measured in 11 female and 10 male participants during two phases of dental surgery. Participants that were higher on trait anxiety had lower parasympathetic activation during the expectation of the surgery compared to low trait anxiety participants. High anxiety participants also did not show parasympathetic reactivity (i.e. vagal withdrawal) during the next phase, which was evident only in low trait anxiety participants. Such a pattern was not observed for the other components of trait of neuroticism. The results were interpreted in the context of lower psychophysiological flexibility and poorer coordination of different emotional systems in high trait-anxiety individuals.

Key words: parasympathetic activation, trait anxiety, dental surgery

Introduction

Autonomic nervous system consists of two branches; the sympathetic nervous system (SNS), associated with the ''fight or flight'' response, and the parasympathetic nervous system (PNS), associated with rest and digestive activity (Thayer & Brosschot, 2005; Thayer & Lane, 2009). During periods of relative safety and stability, the PNS is dominant and it maintains a lower degree of physiological arousal. During physical or psychological stress, withdrawal of PNS activation results in dominant activation of SNS. The activation of brain circuits that are related to PNS is inversely related to negative emotional arousal; similarly PNS itself acts as a constantly activated brake that inhibits internal cardiac pacemaker which would otherwise make heart rate much faster. Because it is related to the activity of nervus vagus, constant influences of PNS on the heart activity is referred to as vagal activation or vagal tone - VT (Porges, 1995). Respiratory sinus arrhythmia (RSA), or high-frequency heart rate variability (HF HRV), is an approximate index of vagal activation, and it has attracted much attention in psychophysiology within last two decades (Ritz, 2009).

Emotions that are related to fight or flight response, e.g. fear and anxiety evoked by the speech preparation paradigm, are followed by decreases in VT (Pauls & Stemmler, 2003). On the other hand, in research conducted by different authors (e.g. Kreibig, Wilhelm, Roth, & Gross, 2007; Palomba, Sarlo, Angrilli, Mini, & Stegagno, 2000) there were no changes in VT during the induction of fear or anxiety. Absence of consistent relations between changes in vagal activation and emotions of fear and anxiety could be attributed to stable individual differences i/e personality traits, because variations in personality could predispose different individuals to react in different ways to the same situations. By the Porges' Polyvagal theory (Porges, 1995) and Thayer and Lane' model of neurovisceral integration (Thayer & Lane, 2000), parasympathetic inflexibility is related to poorer functioning of emotional and regulatory mechanisms. Thayer and Lane propose that HF-HRV is an index of central-peripheral feedback capacity of the organism that affects the subject's ability to allocate psycho-physiological resources to meet environmental demands (Thayer & Lane, 2000). Those organisms, within a single species, that show more flexible responding of PNS are better adapted and this is related to higher baseline parasympathetic activation. In other words, those individuals with higher baseline parasympathetic activation have the greater capacity to react with the withdrawal of parasympathetic activation when this is required by a given situation. Accordingly, low VT is found to be connected with trait anxiety in adults (Bleil, Gianaros, Jennings, Flory, & Manuck, 2008; Miu, Heilman, & Miclea, 2009) and high baseline VT predicts the degree of vagal reactivity (Gračanin, Tončić, & Kardum, 2010; Heponiemi, Keltikangas-Järvinen, Kettunen, Puttonen, & Ravaja, 2004). However, there are numerous reports of enhanced autonomic reactivity to experimental stimuli in patients with anxiety disorders, consistent with the view that anxiety may be associated with exaggerated autonomic reactivity (Hoehn-Saric & McLeod, 1993). Importantly, a great number of studies have not observed heightened autonomic responding, or in fact have reported reduced responses in anxiety disorders (Hoehn-Saric, McLeod, & Hipsley, 1995; Mauss, Wilhelm, & Gross, 2003; Roth et al., 1992). In some cases, a reduction in autonomic reactivity may appear because of the elevated baselines or because of the autonomic adaptation in chronic anxiety states (Berntson, Sarter, & Cacioppo, 1998). For example, general anxiety disorder (GAD) patients are characterized by lower VT relative to controls during rest, while the decreases in vagal tone during aversive imagery and worry expectedly appear in normal subjects but are small or absent in GAD patients (Lyonfields, Borkovec, & Thayer, 1995). To summarize, it appears that anxious individuals are characterized by lower VT during baseline (and probably during other conditions), and by smaller decreases in VT during negative emotion.

Studies of relations between trait anxiety and vagal activation in non-clinical population are scarce and there are no such studies in the context of dental surgery which is an important trigger for anxiety states (Kleinknecht, Klepac, & Alexander, 1973; Smith & Heaton, 2003). The aim of the present study is to investigate the differences in vagal activation between high and low trait anxiety subjects throughout two phases of dental surgery. The first phase – the waiting time before the surgery – is expected to be of great importance in the context of trait anxiety. Namely, although the phase itself does not pose a real threat of damage or pain, high-anxious patients should find it more stressful compared to those that are low on this trait. The second phase – after the injection of anesthesia – represents the period in which the operation has gone under way and where the situation should become more stressful. It is expected that during this period, low-anxious patients react with moderate vagal withdrawal, whereas those high-anxious, that have less flexible vagal capacities, are not expected to show such a response. To test the specific hypothesis about the lower vagal flexibility in more anxious subjects in anxiety provoking situation (the surgery itself), the role of possibly confounding personality traits is going to be taken into account: angry hostility, depressiveness and impulsiveness. These traits are, together with the trait of anxiety, components of the broader factor of neuroticism and are expected to be related to lover VT. Anyway, they are not expected to be related to reactions in the anxiety provoking situation. In addition, it is expected that the effects of surgery phase on VT are going to be more evident in less anxious patients when they report more fear, while this emotion is not going to have any impact on vagal activation in more anxious (less vagally flexible) subjects.

Methods

Participants

All the patients of the Department of Oral Surgery at the School of Dental Medicine in Zagreb, who needed third molar surgical removal (alveolotomy) in the period of two months during which the data was collected were potential participants of the present research. The total number of the patients who met these criteria was 35 and they were all invited to participate in the research. Of those 35 patients 32 gave their consent. Since 11 participants had to be excluded from the study due to technical problems with portable cardio-recorders, the final sample consisted of 11 female and 10 male participants, mean age of 27.5 years (age range 18-46 years). All the patients were operated by the same oral surgeon.

Measures

Psychological measures. To measure four traits of interest, four scales of neuroticism facets (anxiety, depressiveness, angry hostility and impulsiveness) from the questionnaire NEO-PI-R (Costa & McCrae, 2005) were employed. Each scale consists of eight items in the form of short sentences (e.g. I rarely feel anxious or fearful) which are answered on a 5-point Likert scale. To measure subjective experience of fear, the corresponding scale from the Emotional states questionnaire (Kardum & Bezinović, 1992) was employed. The scale consists of 10 items in the form of adverbs (e.g. fearful) answered on 5-point Likert scale. Reliabilitiy coeficients (Cronbach Alpha) for the four neuroticism facets on this sample range from .64 (angry hostility) to .75 (depressiveness), which can be considered relatively low but still acceptable in the context of small number of participants. Cronbach Alpha for the fear scale on this sample is .95.

Electrocardiographic measures. The electrocardiographic recordings were obtained using a cardiorecorder (Polar RS 800®—Polar electro Oy, Kempele, Finland) at the frequency of 1000 Hz and segment/phase recording duration of 60 seconds.

Procedure

Patients received questionnaire measuring neuroticism facets on the day they scheduled surgery (approximately 15 days prior to surgery) and the fear scale immediately after the surgery.

The first electrocardiographics recording was obtained after the patient has seated on the surgical chair and the second was obtained immediately before the anesthesia injection (mandibular and plexus local injection). Each RR interval (time intervals between each heart beat) was checked for errors and corrected inside Polar Protrainder software according to the Task-Force guidelines (Task Force of the European Society of Cardiology and the North American Society of Pacing Electropsysiology, 1996). The series of RR intervals was de-trended using a smoothing priors method. To obtain the frequency domain index of vagal influences on the heart (a power of the spectrum) a Fast Fourier transformation method was adopted as recommended by the Task Force of European Society of Cardiology (Task Force Gudelines, 1996) using the Kubios HRV Analysis Software provided by the Biomedical Signal Analysis Group from Kuopio, Finland. High frequency (HF, 0.15 – 0.40 Hz) spectral component, which is known to represent parasympathetic activity, has been derived. HF HRV was additionally corrected for RR (the square root of the spectral power of high frequency RR (ms^2) divided by the mean RRI (ms) was used). Such corrected index is proven to be more sensitive to vagal blockade than more commonly used indices of cardiac vagal activation and by using such correction more meaningful relations with other important variables are usually obtained (Gračanin et al., 2010; Scheinin et al., 1999).

Results

Obtained descriptive data, for each of the contrasted groups, are presented in Table 1.

To test the main effects and interaction between the surgery phase and traits of anxiety, depressiveness, angry hostility and impulsiveness as well as the subjective experience of fear, four mixed model ANOVAs (2*2*2) have been computed. Thus, each ANOVA included a within-subjects variable (surgery phase) and between-subjects variables (the neuroticism facet of interest and the subjective experience of fear) with two levels (low or high, categorized on the basis of median values). There were no statistically significant main effects and, as expected, only the interaction between the surgery phase and trait anxiety was found to be statistically significant [$F(1,17) = 9.23$; $p < .01$; $\eta^2 = .35$]. As can be seen from the Figure 1, VT was initially higher but it slightly decreased in less anxious patients, while it even increased in more anxious patients. It appears that lower trait anxiety is related to vagal withdrawal during the formally more stressful situation as well as to higher VT during the expectation of the surgery. On the other hand, more anxious individuals exhibited lower VT during the expectation, while in the next phase their vagal activation greatly increased.

Table 1
Vagal tones of four neuroticism facets (low and high levels) depending on the surgery phase

Neuroticism facet	Level	Surgery phase	*M*	*SD*	*Skewness*	*Min*	*Max*
Anxiety	low	waiting period	.0295	.0108	0.362	.0158	.0464
		operation onset	.0270	.0071	1.092	.0190	.0420
	high	waiting period	.0220	.0106	0.452	.0107	.0384
		operation onset	.0344	.0153	0.550	.0157	.0640
Angry hostility	low	waiting period	.0281	.0110	0.809	.0158	.0464
		operation onset	.0283	.0086	0.416	.0184	.0420
	high	waiting period	.0241	.0113	0.046	.0107	.0384
		operation onset	.0326	.0147	1.027	.0157	.0640
Depressiveness	low	waiting period	.0246	.0100	1.091	.0130	.0454
		operation onset	.0322	.0135	1.546	.0190	.0640
	high	waiting period	.0316	.0117	-0.304	.0116	.0464
		operation onset	.0256	.0116	0.536	.0157	.0495
Impulsiveness	low	waiting period	.0257	.0100	0.688	.0130	.0454
		operation onset	.0324	.0133	1.584	.0190	.0640
	high	waiting period	.0262	.0125	0.163	.0107	.0464
		operation onset	.0289	.0112	0.682	.0157	.0495

Statistical testing did not reveal any other effects. The interactions between surgery phase, the subjective experience of fear and all four neuroticism facets were not significant. Furthermore, there were no interactions between the other three neuroticism facets and surgery phase.

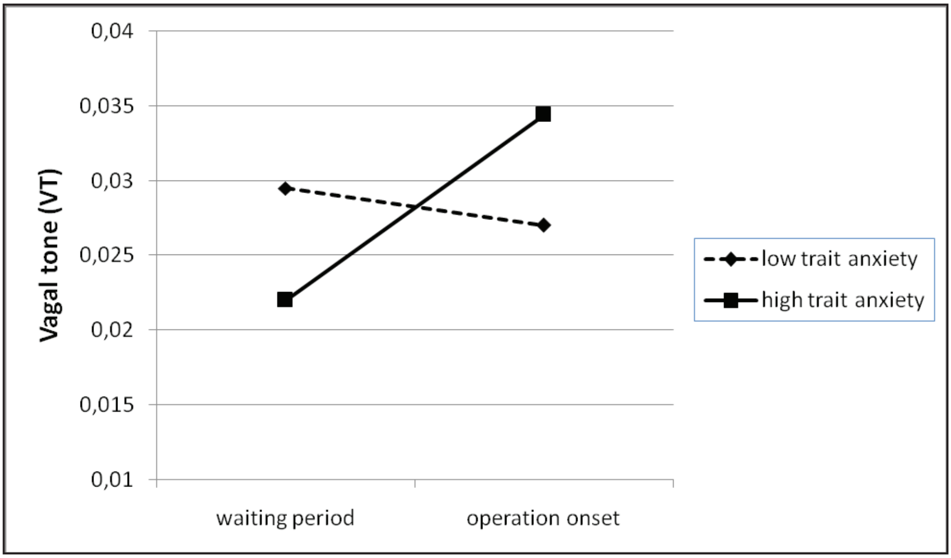

Figure 1. *Interaction between trait anxiety and surgery phase on VT*

Discussion and Conclusions

Decreases in VT are a normative reaction to stressful situations; e.g. decreases in HF HRV are observed as a response to fear inducing film in 7-year olds (Gilissen, Bakermans-Kranenburg, Van IJzendoorn, & Van Der Veer, 2008). Similarly, subjects who increased cortisol exhibited a decrease in cardiac VT while subjects who decreased cortisol exhibited an increase in cardiac VT (Doussard-Roosevelt, Montgomery, & Porges, 2003). Furthermore, constantly decreased parasympathetic cardiac control has been reported for generalized anxiety disorder (GAD) patients meeting DSM-III-R criteria (Lyonfields et al., 1995; Rechlin, 1994). Importantly, patients with GAD showed diminished vagal control of the heart also during relaxation (Thayer, Friedman, & Borkovec, 1996). In general, it appears that anxious individuals are characterized by a lack of behavioral flexibility and by an inability to generate an appropriate response to the changing environmental demands (Hoehn-Saric et al., 1995; Thayer et al., 1996). More specifically, results of this study have shown that, in accordance with the Polyvagal theory and the model of neurovisceral integration, individuals who are characterized by higher trait anxiety t show less flexible or less appropriate vagal responding (they increase their vagal activity when a withdrawal is expected) compared to low trait anxious individuals. Such a result is for the first time obtained in the context of expectation and the process of dental surgery. This type of procedure, as mentioned earlier, is a more ecologically valid than experimental manipulation. It is worth noting that higher anxious patients responded with increased vagal activity suggesting their increased need to return to homeostasis, while less anxious patients responded with a normative withdrawal as expected (Lyonfields et al., 1995; Porges, 1995; Thayer & Lane, 2000; Thayer & Brosschot, 2005).

Such relations were not observed for the other components of neuroticism which points to the specific relation of trait anxiety to parasympathetic flexibility. It appears that among different traits that are related to experience of negative affect, only trait anxiety is relevant for the parasympathetic activation in the context of dental surgery. Furthermore, results have shown that subjective experience of fear during the whole surgery has no impact on this relation. However, the role of subjective experience of fear during different phases of such a stressful event should be investigated in future studies.

Results of this study additionally accentuate the importance of autonomic inflexibility in relation to anxiety, which is in accordance with the Polyvagal theory and the model of neurovisceral integration. Moreover, the findings of the present study are relevant because of their practical implications. It could be beneficial to assess trait anxiety before potentially stressful oral operations and to administer anxiety reducing medication to patients high on trait anxiety, or to submit them to a short psychological treatment.

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CRTA ANKSIOZNOSTI KAO MODERATOR EFEKTA DVE FAZE DENTALNE OPERACIJE NA VAGALNU AKTIVACIJU

Smanjenje parasimpatičke (PNS) aktivacije je normativan odgovor na stresnu situaciju. Prema Porgesovoj Polivagalnoj teoriji (Porges, 1995) i Thayerovom i Laneovom (2000) modelu neurovisceralne integracije, nefleksibilnost PNS-a je povezana sa slabijim funkcionisanjem emocionalnih i drugih psihičkih regulatornih mehanizama. Cilj ovog istraživanja bio je istražiti razlike u aktivaciji PNS-a između visoko i nisko anksioznih ispitanika kroz dvije faze operacije zuba – tokom čekanja da operacija počne i nakon primanja injekcije s anestezijom, za koju se očekivalo da će biti stresnija. Aktivacija PNS-a, definisana kao visoko-frekventna varijabilnost rada srca, merena je kod 11 ženskih i 10 muških ispitanika tokom dvije faze operacije zuba. Ispitanici koji su bili viši na crti anksioznosti imali su nižu parasimpatičku aktivaciju tokom čekanja operacije u odnosu na nisko anksiozne ispitanike. Visoko anksiozni ispitanici, takođe, nisu pokazali parasimpatičku reaktivnost (tj. vagusno povlačenje) tokom sledeće faze, dok je ona bila prisutna kod anksioznih ispitanika. Rezultati su interpretirani u kontekstu manje psihofiziološke fleksibilnosti i slabije koordinacije različitih emocionalnih sistema kod visoko anksioznih pojedinaca.

Ključne reči: parasimpatička aktivaijca, crta anskoznosti, dentalna operacija