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Anger and cardiovascular startle reactivity in normotensive young males

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ABSTRACT

Anger has been implicated in the etiology of hypertensive disease. Trait anger has been linked to enhanced cardiovascular responsiveness. However, whether this association reflects differences in context appraisal or a general hyper-reactivity of the cardiovascular system remains unclear. We studied the cardiovascular response to acoustic startle probes in 76 healthy Caucasian males in different affective contices (pleasant, neutral, and unpleasant). All participants completed the State-Trait-Anger-Expression-Inventory (STAXI) by Spielberger and the results were analysed with stepwise regression analysis according to the anger scores and traditional risk factors for hypertension. Our study reveals differential modulation of the cardiovascular response to startle stimuli by affective pictures in the dimensions "valence" for heart rate and "arousal" for blood pressure. Anger-in was identified as the most important determinant for blood pressure responses in unpleasant context, while anger-out was associated with less cardiovascular activation in neutral context. This is the first study that relates trait anger to cardiovascular reactivity and affective reflex modulation in normotensive subjects. We could demonstrate an interaction of affective context and trait anger for cardiovascular (hyper-)reactivity. Increased cardiovascular reactivity for higher scores of anger-in in unpleasant context may indicate enhanced sympathetic reactivity and constitute a risk factor for the development of essential hypertension.

1. Introduction

The prevalence of hypertension has been rising continuously in modern society. The contribution of psychosocial factors such as suppressed anger has been suggested early in hypertension research (Alexander, 1939). Anger has repeatedly been linked with the etiology of essential hypertension (Deter et al., 2001; Dimsdale et al., 1986). A recent review found a consistent association of trait anger and ambulatory blood pressure (Schum et al., 2003). It has been hypothesized that trait anger causes increased physiological arousal by interacting with situational factors (Jorgensen et al., 1996). In line with this, trait anger has been linked to enhanced cardiovascular reactivity (Bongard et al., 1998; Vogele et al., 1997) and increased sympathetic activity (McCraty et al., 1995). Indeed, a functional blood pressure rise in stressful situations can precede a permanently elevated blood pressure that is solidified by structural changes of the arteries (Schlaich et al., 2004). Furthermore, enhanced sympathetic activity can promote later hypertension without preceding blood pressure elevations. Enhanced sympathetic activity unfolds deleterious effects on the cardiovascular system (Mancia et al., 1999), promoting media sclerosis and heightened vascular resistance (Ferriss, 1978; Markovitz et al., 1993).

However, little is known about the affective modulation of blood pressure responsiveness and the relationship between anger and cardiovascular reactivity in a healthy population. Especially "anger-in", i.e. anger directed towards the own person, held or suppressed anger feelings, and "anger out", i.e. overtly and directly expressed anger towards other persons or environmental objects (Forgays et al., 1997) appear to be positively correlated with resting systolic blood pressure (Bongard and al'Absi, 2005; Igna et al., 2009; Vogele and Steptoe, 1992). Negative correlations with resting diastolic blood pressure have been reported (Schum et al., 2003; Spicer and Chamberlain, 1996), but contradictory findings exist (Holroyd and Gorkin, 1983; Igna et al., 2009; Shapiro et al., 1997). "Anger-in" is also positively correlated with systolic blood pressure reactivity during stressful tasks (Burns, 1995; Holroyd and Gorkin, 1983; Mills and Dimsdale, 1993; Vogele and Steptoe, 1992), while mixed results exist for "anger-out". Although consistently associated with higher systolic blood pressure at rest, both positive (Burns, 1995; Faber and Burns, 1996; Vogele and Steptoe, 1992) and negative (Haeri et al., 1996;

Abbreviations: ECG, electrocardiogram; EMG, electromyogram; BMI, body mass index; SU, standardized units; mmHg, millimeter mercury; bpm, beats per minute; IAPS, International Affective Picture System; STAXI, State-Trait-Anger-Expression-Inventory; SAM, Self-Assessment Manikin questionnaire.

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Holroyd and Gorkin, 1983; Vogele and Steptoe, 1992) correlations with systolic blood pressure reactivity to stress have been reported.

Assessing cardiovascular stress reactivity in subjects differing in trait anger may potentially be biased by differences in task perception. The startle reflex represents a valuable tool for the investigation of cardiovascular responses to external stimulation and the modulation of such responses by affective context. In contrast to other stimuli that are commonly used to elicit a cardiovascular reaction (e.g. math task, cold pressor, interview stress, etc.), the startle reflex is brainstem relayed and therefore does not require higher cognitive processing of the eliciting stimulus itself.

The startle reflex is part of the defensive reflex system and accompanied by a cardiovascular response consisting of a rise in heart rate and blood pressure (Girard et al., 2001; Holand et al., 1999a; Holand et al., 1999b). The amplitude of the motor response (as measured by electromyogram of the musculus orbicularis oculi) is enhanced in negative affective context (match condition: when the context matches the aversive character of the reflex) and diminished in positive affective context (mismatch condition). The same pattern of modulation has been found for heart rate responses to startle stimuli (Bradley et al., 1990; Cook et al., 1992; Gautier and Cook, 1997). Although some studies reported inconsistent results for reactions in pleasant context (Bradley and Lang, 2000; Sanchez et al., 2002), these studies demonstrate an affective modulation of the heart rate reaction that is elicited by the brainstem mediated startle reflex. The affective modulation of the blood pressure response to startle stimuli has, to our knowledge, not been investigated yet, but there is evidence that enhanced affective startle modulation is associated with generally enhanced blood pressure reactivity. Gautier and Cook found enhanced affective startle modulation in individuals with enhanced blood pressure response to mental stress (Gautier and Cook, 1997). Also, enhanced affective startle modulation has been linked to physiological characteristics such as salt sensitivity and psychological states or traits such as anxiety, irritability, and anger (Buchholz et al., 2001) that in turn are considered risk factors for hypertension.

In this study, we investigated the affective modulation of heart rate and blood pressure responses to startle stimuli in normotensive subjects. We furthermore investigated how anger affects the cardiovascular response to startle stimuli. Trait "anger expression" (with the dimensions “anger-out" and “anger-in”) as well as trait “anger control” were assessed with the German version of the State-Trait-Anger-Expression-Inventory (STAXI). Pictures of different emotional content (valence) and acoustic startle stimuli were presented to the participants while startle magnitude, heart rate, and blood pressure were recorded. Self-ratings of the visual stimuli were obtained to control for differences in perceived affective stimulation and correlated with anger scores.

We hypothesized that the startle reflex would be accompanied by a significant cardiovascular response (i.e. an increase of heart rate and blood pressure) modulated by affective context (i.e. an increase in unpleasant context, and a decrease in pleasant context). We furthermore assumed that trait anger would have a significant effect on the cardiovascular response to startle stimuli. We hypothesized that this effect would be independent of affective context in case of a general hyper-reactivity of the cardiovascular system, or depending on affective context in case of an underlying difference in context appraisal.

2. Methods

2.1. Participants

We recruited healthy male volunteers for the study via advertisement on university black boards. The relationship between trait anger and blood pressure may be affected by gender (Durel et al., 1989; Ewart and Kolodner, 1994; Shapiro et al., 1995), hereditary factors (Lawler et al., 1998; Shapiro et al., 1995; Vogele and Steptoe, 1992), and ethnic background (Durel et al., 1989; Ewart and Kolodner, 1994; Shapiro et al., 1995). To control for these factors, only healthy Caucasian males were included into the study sample and family history of hypertension was assessed during the medical screening.

We included 80 volunteers. Four of these had to be excluded from statistical analysis. Two participants demonstrated repeatedly elevated blood pressure in the experimental setting (>160 mmHg) and two others had to be excluded due to technical difficulties during the recordings. Applicants with known cardiovascular disease, other acute or chronic illnesses, smokers, and shift workers were excluded. All participants underwent routine physical examination. Participants had a mean age of 25.5 ± 2.6 years and a BMI of 22.8 ± 2.3 kg/m². Mean systolic blood pressure on physical examination prior to the test was 110 ± 7.8 mmHg, mean diastolic blood pressure 55.8 ± 5 mmHg, and mean heart rate 57.7 ± 8.6 beats per minute. Mean values for physical activity (subjective rating scale, see below) were $1.9 \pm .78$ arbitrary units. The study was approved by the local ethics committee of the hospital (University Hospital Benjamin Franklin, Berlin, Germany). All participants gave written consent before being included and were free to leave the study at any point.

2.2. Stimulus material

The affective pictures were selected from the International Affective Picture System (IAPS) (Lang et al., 1988). The IAPS is a well established method for affective stimulation. The system contains a large number of slides that have been rated for valence (i.e. the emotion elicited by the slide ranging from “unpleasant = 0” to “pleasant = 9”) and arousal (i.e. how much arousal is elicited by the slide ranging from “low = 0” to “high = 9”). Pleasant (e.g. nature scenes, erotic pictures), neutral (e.g. household items, colored textures), and unpleasant pictures (e.g. fierce animals, mutilation pictures) were presented.[1] Slides were selected to have equal ratings for valence within each category (pleasant: 7.6 (sd = 0.54); unpleasant: 2.8 (sd = 0.65); neutral: 5.09 (sd = 0.28)) based on the original IAPS ratings by Lang et al. (1988). Positive and negative slides were selected to have comparable ratings for arousal (5.84 (sd = 1.05) and 5.93 (sd = 0.92), respectively). Neutral slides are generally rated as less arousing (3.22 (sd = 1.0)). The startle stimuli consisted of 95 dB white noise of 50 milliseconds duration and instantaneous rise time (noise generator provided by Dr I. Curio, Medizinelektronik, Bonn, Germany).

2.3. Questionnaires

All participants completed a questionnaire assessing traditional risk factors for hypertensive disease, i.e. family history of hypertension, age, BMI, and physical activity. Participants were categorized as positive for “family history of hypertension” if at least one first grade relative had a history of clinically relevant hypertensive disease. Physical activity was assessed on a subjective rating scale ranging from 0 (no physical activity) to 3 (high level of physical activity, e.g. regular endurance training).

[1] Complete list of IAPS-pictures used in the experiment: Original ratings for valence and arousal are presented in brackets (valence/arousal). Pictures in brackets were not included into statistical analysis, because they were followed or preceded by another startle in too close temporal relationship. Pleasant pictures: 1710 (8.02/5.53), 8200 (7.15/6.33), 7580 (7.4/5.08), 4250 (8.39/7.02), 1750 (7.89/4.21), 7230 (7.42/5.81), 2160 (6.87/5.31), 4180 (8.21/7.43), 1600 (6.95/4.08). Unpleasant pictures: 6360 (2.63/5.8), 6230 (2.73/7.1), 2800 (2.31/4.94), 6540 (2.53/6.51), 1120 (4.73/6.6), 9140 (2.56/4.9), 1300 (4.06/6.9), 2120 (3.65/4.93), 3030 (2.31/6.39). Neutral pictures: 7550 (5.39/4.48), 7010 (4.95/1.55), 7130 (4.79/3.54), 9070 (4.88/3.51), 7830 (5.31/4.40), 7090 (4.95/2.30), 7100 (5.29/3.08), 2190 (4.73/2.27), 7190 (5.5/3.89)