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Perception of Heart Rate and Blood Pressure: The Role of Alexithymia and Anxiety

Key Words

Alexithymia
Anxiety
Awareness
Heart rate
Blood pressure

Abstract

While the ability to estimate heart rate in a laboratory setting appears to be related to anxiety and alexithymia, it is still unclear how the ability to estimate blood pressure is related to these psychological measures. The perception of heart rate and blood pressure in 24 normotensive subjects with varying degrees of alexithymia and anxiety was examined. Results indicate that the estimation of heart rate is related to psychological characteristics, while the estimation of blood pressure is not. More anxious subjects perceived heart rate more accurately than less anxious subjects. Furthermore, high alexithymic subjects perceived heart rate less accurately than low alexithymic subjects. The accuracy of estimation of blood pressure was, however, not related to alexithymia or anxiety. These findings provide further evidence that blood pressure estimates in a laboratory setting are mainly based upon situational cues.

Approximately 25–30% of normotensive as well as hypertensive individuals are able to accurately estimate their blood pressure (BP) [1]. Normotensives can learn to estimate BP more accurately through specific training and education. Training is based upon an assessment of the individual-specific relation between BP and various bodily symptoms and moods that subsequently can be used to esti-

mate BP [2]. A prerequisite for such an assessment is that individuals are able to accurately perceive symptoms and moods; an ability that varies among people.

The perception of physical symptoms has primarily been studied from the perspective of psychopathology and personality theory. In particular the relation between anxiety disorders and the perception of heart rate (HR) has

Table 1. Subject characteristics

	Mean	SD
Age, years	26.7	9.1
Weight, kg	74.3	7.8
Height, cm	182.9	7.5
BMI, kg/cm ²	22.2	2.5
Alexithymia	102.7	14.0
Trait anxiety	37.1	8.2
State anxiety	33.4	6.0

received much attention. Patients with cardiac phobia, panic disorder, other anxiety disorders, and hypochondria perceive HR more accurately than healthy control subjects [3]. Patients with panic disorder or generalized anxiety disorder also perform better in a heartbeat perception task than patients with depression [4]. Among normal subjects, a comparison between good and poor perceivers of HR revealed a significant difference in state anxiety and emotional lability [5].

Whereas the previous studies focus on anxiety and the perception of HR, others draw attention to the role of alexithymia on general subjective physiological responses to stress [6]. The personality construct alexithymia is characterized by an inability to identify and describe feelings, by a constricted fantasy life, and by a concrete and reality based cognitive style (*la pensée opératoire*). The limited emotional awareness in alexithymics is thought to lead to a misinterpretation of the somatic symptoms of emotional arousal and subsequently to somatization [7]. Experimental evidence for a decoupling of HR and the subjective report of tension was found in alexithymics following a stress quiz [8, 9].

Whether BP is perceived directly or inferred indirectly from the perception of more readily observable physical symptoms and moods is not clear. In both cases an adequate

perception of one or more physiological responses is required. As accurate HR estimation is only moderately related to accurate BP estimation [2], it is likely that we are dealing with different abilities. The ability to estimate HR appears to be related to anxiety and alexithymia [3, 9], but it remains unclear how the ability to estimate BP is related to these psychological measures. The present experiment examines how the perception of HR and BP in a laboratory setting is related to alexithymia and anxiety.

Method

Subjects

Subjects were recruited through posters in university buildings in which a fee of 40 Dutch guilders (approximately US\$ 20.00) for participation was offered. Inclusion criteria were (1) age between 24 and 50; (2) normal BP according to WHO criteria and no history of hypertension. All subjects were either students or teachers. Means and standard deviations of age, weight, height, body mass index (BMI), alexithymia, and trait and state anxiety of the 24 male subjects are given in table 1.

Materials

BP Measuring Device. Systolic BP (SBP), diastolic BP (DBP), and HR were measured with a Dinamap model 845 (Applied Medical Research Corporation) at the start of a session. During tasks and rest periods SBP, DBP, and HR were measured with a FinapresTM Model 5 (TNO, The Netherlands), an instrument that reliably measures BP from the finger [10]. A detailed description of the equipment is published elsewhere [11]. Because SBP and DBP are highly correlated and because previous reports indicate more symptom-BP correlations with SBP than with DBP we will only analyze relations with SBP.

Questionnaires. At the start of the session subjects completed the State-Trait Anxiety Inventory [12] and the Bermond Vorst Alexithymia Questionnaire [13]. The Bermond Vorst Alexithymia Questionnaire consists of five 8-item subscales that measure the characteristics of the alexithymia construct as described by Taylor et al. [14]. In addition to the four factors of the Toronto Alexithymia Scale, the questionnaire measures an impoverished emotional life, called Low-

Emotionality, which element was omitted from the Toronto Alexithymia Scale (TAS) [14]. Cronbach's alpha of the scales Verbalise, Fantasize, Insight, Pénée opératoire, and Emotionality, based on a sample of 465 psychology students, are 0.89, 0.88, 0.78, 0.81, and 0.77 [13].

Tasks. Most tasks that the subjects performed were the same as those in a study by Barr et al. [2]. Each task lasted approximately 1 min and was followed by a 1-min rest period. The tasks were presented in the following order for all subjects: squeezing a rubber ball, alternately raising each leg, forced breathing, two periods of relaxation, mental arithmetic, calling out words starting with the letter T, talking about work, talking about a personality trait that friends would like you to change, singing the national anthem, and imagine being very angry. We told subjects that a rest period always followed a task period in order to allow the influence of a task on SBP and HR to wane out before another task was presented.

BP and HR Estimates and List of Symptoms and Moods. The experimenter informed subjects about their present SBP level (in mm Hg) before the first task and told them their SBP could fall 30 mm Hg below and could rise 30 mm Hg above the present level during the experiment. He asked them to give BP estimates in this range. Because an explicit estimate of HR in beats per minute would deviate from the study of Barr et al. [2], we preferred to use two indirect HR estimates of the subjects via 'pounding heart' and 'fast pulse'. These HR estimators were included in a longer list of symptoms and moods.

As BP is influenced by a variety of regulating mechanisms [15] and changes in BP are not logically linked to specific symptoms, we selected symptoms from each of the groups of physical symptoms described in the Hamilton Anxiety Scale [16] with an exception for urogenital symptoms. Coverage of the lists of symptoms used in other studies was ensured by adding the symptom headache [1, 17, 18]. The list of symptoms consisted of: tense muscles, warm body, cold hands, fast pulse, pounding heart, tight chest, shortness of breath, heavy breathing, irritated bowels, dry mouth, blushing, turning pale, perspiring, dizziness, headache, and sweaty hands. The list of moods was based upon the lists used in the Pennebaker studies and consisted of the following seven moods: excited, angry, rushed, energetic, happy, afraid, and relaxed. During a pilot study the moods frustrated and sad were included in the list, but since none of the participants displayed variability on these variables, they were omitted. The list of internal and external symptoms was attached on a board in front of the subject. Subjects received

instructions to give scores from 0, representing the absolute absence of a symptom or mood, to 10, the highest intensity they had ever experienced. Furthermore, subjects were encouraged to use a wide range of scores in order to report even minor fluctuations in symptoms and moods.

Data Reduction and Analysis

Ten SBP and HR measurements were obtained during the 20 s immediately following a task or rest period. The average of the last five of these measures, which showed sufficient stability, was used for further analyses.

Although the within-subject design contains rest periods to prevent an accumulation of physiological reactions, an exact recapture of baseline level is not guaranteed. The presence of time trends in SBP, HR, and in estimates of SBP and HR during rest periods [19] was therefore investigated by testing the goodness of fit of 1st, 2nd, and 3rd order polynomials. When trend was present, residuals of task and rest periods on these polynomials were calculated, otherwise no correction was applied. Pearson product moment correlations were calculated on these corrected scores in order to assess the degree of association between actual SBP and HR and estimated SBP and HR. We applied a significance level of 0.05 for separate correlations of BP measurements with BP estimates and of HR measurements with HR estimates, which results in a correlation of 0.43 being significant.

Fisher's r to Z transformation was applied to the correlations. Subsequently, differences between subgroups of subjects in the size of correlations were tested using analysis of variance. Group differences between BP, HR, and subjective scorings during the experiment were analyzed using repeated measures analyses of variance.

Procedure

After entering the experimental room, subjects received a short explanation of the procedure to be followed and then signed a declaration of informed consent. They were then left alone to complete the two questionnaires.

After about 10 min the experimenter reentered the room and asked the subject to sit down in a special chair. This chair was similar to a child's high chair as it had a tabletop that could be rotated under the left elbow rest. Furthermore, this tabletop could be adjusted in height allowing the cuff of the Finapres to be placed in front of the lower end of the sternum. When the subject was seated and the tabletop placed in position, the experimenter placed the cuff of the Dinamap on

the right arm and the cuff of the Finapres on the left ring-finger. The Finapres was started and the subject was asked to relax. After 10 min three Dinamap BP measurements, spaced 2 min apart, were taken.

The experimenter then gave instructions for the first task. After the task, BP and HR measurements were stored, and the subjects were asked to estimate BP and to give ratings on each of the symptoms and moods. After a 1-min rest period, a BP estimate and ratings were again requested. The other 10 tasks similarly alternated with rest periods. Two weeks after the testing session subjects returned to the laboratory and received information on their results.

Results

Formation of Subgroups

Subjects were divided into two groups according to their alexithymia scores which were based on normtables [13], 12 in the lower seven percentiles, 12 in the upper three percentiles. State anxiety and trait anxiety were significantly related in our sample, $r = 0.46$, $p < 0.05$. As previous reports on normal subjects indicate a relationship between state anxiety and accuracy of HR perception, we will only present analyses on state anxiety. Subjects were assigned to a group low in state anxiety, 13 in the lower five percentiles, and high in state anxiety, 11 in the upper five percentiles [12]. Raw alexithymia and state anxiety scores and group membership based upon these scores were not related in our sample, $r = 0.29$, NS and $\chi^2 = 0.67$, $p = 0.41$.

Estimates of BP and HR

BP Estimates. The average correlation between estimated SBP (ESBP) and SBP was 0.31, SD 0.25. While 22 subjects had a positive correlation, only 2 had a negative correlation. Eleven subjects had significant correlations of SBP with ESBP.

A 2 (State Anxiety) $\times$ 2 (Alexithymia) analysis of variance on Z-transformed correlations of SBP with ESBP resulted in a nonsig-

nificant factor Alexithymia, $F(1, 20) = 0.04$, $p = 0.85$, a nonsignificant factor State Anxiety, $F(1, 20) = 0.66$, $p = 0.43$, and a nonsignificant interaction, $F(1, 20) = 2.49$, $p = 0.13$. The average correlation in subgroups is shown in table 2.

HR Estimates. Two subjects showed no variability on fast pulse and one of these also displayed no variability on pounding heart. These subjects are omitted from analyses on corresponding HR estimators. The average correlation between pounding heart and actual HR was higher than the correlation between fast pulse and HR, 0.24 and 0.11 respectively, $t(21) = 2.06$, $p = 0.05$. Higher correlations of HR with pounding heart than with fast pulse were seen in 13 subjects. The number of subjects that showed significant correlations of HR with pounding heart was 7, with fast pulse 3. Only 1 subject showed significant correlations of HR with both symptoms. Because most subjects gave better HR estimates through scores on pounding heart, scores on fast pulse were not further analyzed.

A 2 (State Anxiety) $\times$ 2 (Alexithymia) analysis of variance on Z-transformed correlations of HR with pounding heart resulted in a significant factor Alexithymia, $F(1, 19) = 10.23$, $p < 0.01$, a significant factor State Anxiety, $F(1, 19) = 10.28$, $p < 0.01$, and a nonsignificant interaction, $F(1, 19) = 0.02$, $p = 0.90$. Table 3 shows the average correlation of HR with EHR for the four subgroups that result from the partitions in alexithymia and trait anxiety.

Only 1 subject displayed significant correlations of both pounding heart with HR, $r = 0.83$, and of ESBP with SBP, $r = 0.43$.

Actual Blood Pressure, Heart Rate, and Subjective Scores in Subgroups

Alexithymia. High and low alexithymic subjects did not differ in average HR, 73.7 and 69.6 bpm, $F(1, 22) = 1.10$, $p = 0.31$, or in

Table 2. Average correlation of BP and estimated BP in subgroups

		Alexithymia	
		low	high
Anxiety	Low	0.52 (8)	0.29 (5)
	High	0.21 (4)	0.39 (7)

Number of subjects in parentheses.

Table 3. Average correlation of HR and estimated HR in subgroups

		Alexithymia	
		low	high
Anxiety	Low	0.26 (8)	-0.15 (4)
	High	0.71 (4)	0.26 (7)

Number of subjects in parentheses.

SBP level, 130.9 and 136.2 mm Hg, respectively, $F(1, 22) = 0.34$, $p = 0.57$, during the experiment. High and low alexithymics did not differ in mean score on pounding heart, 1.87 and 1.16, $F(1, 22) = 1.14$, $p = 0.30$, or ESBP, 112.5 and 120.6, respectively, $F(1, 22) = 1.52$, $p = 0.23$. The mean score on the mood relaxed in high alexithymics, 5.5, is marginally lower than in less alexithymics, 6.6, $F(1, 22) = 3.8$, $p = 0.06$.

State Anxiety. Subjects high and low in state anxiety did not differ in average HR, 72.7 and 70.8 bpm, $F(1, 22) = 0.22$, $p = 0.64$, or in SBP level, 136.3 and 131.2 mm Hg, respectively, $F(1, 22) = 0.31$, $p = 0.58$. The mean score on pounding heart in high state anxious subjects was twice as high as in low state anxious subjects, 2.18 and 0.96, respectively, a marginally significant difference, $F(1, 22) = 3.72$, $p = 0.07$. High and low state anxious subjects were not significantly different in ESBP, 124.5 and 118.6, respectively, $F(1, 22) = 1.55$, $p = 0.23$. High state anxious subjects had significantly lower scores on the mood relaxed than low state anxious subjects, 5.4 and 6.6, respectively, $F(1, 22) = 4.98$, $p = 0.03$.

HR Perception. The sample was divided into good and bad perceivers of HR by a median split of the Z-transformed correlations of HR with EHR. Good and bad HR

estimators did not differ in BP, $F(1, 21) = 0.48$, $p = 0.50$, or in HR, $F(1, 21) = 0.05$, $p = 0.82$.

BP Perception. The sample was divided into good and bad perceivers of SBP by a median split of the Z-transformed correlations of BP with EBP. Good and bad BP estimators did not differ in SBP, $F(1, 22) = 1.36$, $p = 0.26$, but differed in HR, $F(1, 22) = 10.87$, $p = 0.003$. Good BP estimators had a significantly higher HR than bad BP estimators, 77.1 vs. 66.2 bpm.

Discussion

The results indicate that the accurate estimation of HR is related to psychological characteristics, while the accurate estimation of BP is not. More anxious subjects perceived HR more accurately than less anxious subjects. Furthermore, high alexithymic subjects perceived HR less accurately than low alexithymic subjects. The accuracy of BP estimation was not related to alexithymia or anxiety. Good and bad HR estimators did not differ in average HR or BP level, good BP estimators displayed a higher HR level than bad BP estimators, but did not differ in BP level.

The less accurate HR estimation in alexithymic persons provides evidence for a

hypothesized misinterpretation of somatic symptoms in alexithymic persons [20]. The high alexithymics displayed a tendency to be less relaxed throughout the experiment than the low alexithymics, even in the absence of differences in HR or SBP. Papciak et al. [8] suggested a decoupling of autonomic arousal and subjective report in alexithymics only during states of tension, as they found no evidence for a generalized difficulty of expression of feeling states. Using the Profile of Mood States, they observed a difference between alexithymic and nonalexithymic groups in the scores on the subscale Tension after presentation of a stressor. The scores on the subscales Depression, Anger, Vigor, Fatigue, and Confusion did, however, not differ and for HR and SBP an equal increase was observed. Our data replicate this heightened feeling of tension in alexithymics during normal increases in SBP and HR.

A similar mechanism appears to be present in subjects reporting high levels of state anxiety. They feel less relaxed throughout the experiment and feel their heart pound more vigorously than low anxious subjects. Because HR is not higher in high anxious subjects than in low anxious subjects, a heightened awareness of HR activity could be more important in determining level of self-reported anxiety than actual HR activity [5]. Subjects high in state anxiety and subjects high in alexithymia differ, however, in the accuracy of HR perception. In line with other findings [5], high state anxiety and good HR perception are positively related in our subjects. Alexithymia is negatively related to an accurate HR perception. Whereas high state anxiety is accompanied by an increased awareness of cardiac activity, more alexithymic subjects misinterpret cardiac activity.

Good HR estimators do not differ from bad HR estimators in our experiment in HR level. In contrast, a lower HR in habitually

good HR perceivers was reported by Schandry [5], but this finding was not replicated by Knoll and Hodapp [21]. Two recent studies indicate that HR and HR reactivity are of only minor importance for good HR estimation, while cardiac contractility is more relevant [22, 23]. HR may be more relevant for BP estimations as good BP estimators showed a significantly higher HR than bad BP estimators in our experiments. An inspection of the raw data revealed, however, that HR levels below 65 bpm were almost exclusively seen in subjects with very poor BP estimates. Moderate to good HR estimators displayed higher HR levels in a random distribution. A very low HR may impair BP estimation, while a higher HR level only seems to be a prerequisite for accurate BP estimation without actually being of use in making accurate BP estimates.

For both subdivisions of the subjects, the observed sample median was used as a cutoff score. The distribution of the scores on trait anxiety is as one would expect in a random sample, but the scores on alexithymia are surprisingly high. This implies that low alexithymics are underrepresented in our sample. We have no explanation for this overrepresentation of more alexithymic subjects in our self-selected sample as, in general, students and teachers are not more alexithymic than non-students. This bias limits the validity of our findings. The variability in the scores on alexithymia was large enough to detect a relationship between alexithymia and HR estimation. A relationship between alexithymia and BP estimation may, however, only come forth in samples that contain more low alexithymic subjects.

The average correlation between ESBP and SBP is 0.31, which is comparable to reports of 0.33 on male samples in a laboratory setting by Pennebaker and Watson [1] and 0.39 by Smith [cited in 24]. In our study 2

subjects showed negative correlations of only moderate magnitude, -0.05 and -0.15 , whereas others report negative correlations of -0.40 [25]. The percentage of subjects with significant correlations between ESBP and SBP in our study is 46%, which is high compared to 15% reported in the Baumann and Leventhal study [25] and 27% in the Barr et al. study [2]. It is likely that the use of the Finapres contributes to the higher figures in the present study for the following reasons. As the fingercuff of the Finapres operates throughout the experiment, the actual data collection goes unnoticed by the participant. Other devices require the inflation of an arm cuff which is experienced as unpleasant by most subjects and may distract people. Secondly, a BP measurement taken by a Dinamap or by another oscillometric device lasts about 40 s. As ESBP and self-report measures in our study are collected directly after a BP measurement, ESBP and SBP are measured within a shorter time period in our experiment compared to other studies. Lastly, all measures are taken close to the end of a task which, especially after stressful task periods, ensures reports before recovery from stress has taken place.

In the present study good and poor BP estimators could not be distinguished on the basis

of alexithymia or anxiety. Elsewhere it was noted that medicated hypertensives can generally estimate SBP as well as nonmedicated hypertensives or normotensives, but that they do not or cannot perceive internal cues that are correlated with BP, which prevents further training [1]. In a laboratory situation fairly accurate BP estimates can be based largely upon situational cues [24] and the ability to perceive internal symptoms appears only of marginal importance for BP estimation. In training hypertensives to estimate BP more accurately, a focus on the relation of BP with situational variables seems therefore suggested. As medicated hypertensives often hold inaccurate beliefs about symptoms and emotions that covary with BP [25], some attention for internal cues is useful to correct these beliefs. Whether internal cues are only marginally used for BP estimates in a natural environment still needs to be investigated.

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