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Research report

Accurate heartbeat perception in panic disorder: fact and artefact

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Abstract

The hypothesis was investigated that more accurate perception of heartbeats by patients with panic disorder is an artefact of arousal. Twenty-three patients with panic disorder, 16 patients with a mood disorder and 21 normal controls were tested. There were more panic patients who accurately perceived their heart rates ($N = 7$) than depressed patients ($N = 0$) or normals ($N = 2$). The nine accurate perceivers had higher scores on questionnaires measuring the cognitions associated with panic. For non-accurate perceivers, perceived heart rates were unrelated to actual heart rates, unrelated to cognitive factors, but significantly related to arousal. It is concluded that the accurate perception of heartbeats by patients with panic disorder is both fact and artefact: some patients are accurate perceivers, but the majority are not. © 1997 Elsevier Science B.V.

1. Introduction

According to the cognitive model (Clark, 1986), panic attacks are caused by the misinterpretation of benign bodily sensations, for instance palpitations as signs of an impending heart attack. Because of their alleged warning function, patients with panic disorder (PD) tend to be hypervigilant for body sensations, and inadvertently train themselves to perceive sensations that usually go unnoticed. To test this hypothesis, it has been investigated whether PD patients are more accurate at perceiving their heart-

beats than other people. Recently, several studies have been published on this issue, with mixed results.

Ehlers et al. (1995) asked 114 PD patients and 40 normal controls to 'count all heartbeats you feel in your body', during three trials, lasting 25–45 s. PD patients had a significantly lower error score than controls (27.6% vs. 35.1%). With a stricter instruction, however, ('count only those heartbeats about which you are sure') no differences emerged. Part of the patient sample was retested after treatment; no changes were found, and there was a high correlation between error scores before and after treatment. The authors conclude that PD patients are better perceivers of their own heartbeats than controls, and that accuracy of heartbeat perception is rather stable. These findings are a successful replication of an earlier study (Ehlers and Breuer, 1992). This study

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had shown that PD patients perform better on a heartbeat perception test than normal controls, infrequent panickers, patients with simple phobias and depressed patients (but not better than patients with generalized anxiety disorder).

However, Antony et al. (1995) failed to find differences in heartbeat perception among groups of patients with panic disorder, patients with social phobia and normal controls. The groups were tested both at rest and after a period of physical exercise. The same procedure was followed as in Ehlers et al. (1995), but seven trials were administered, ranging from 14 to 22 s in length. The error scores of the PD and control group (27% and 33%, respectively) were quite comparable to Ehlers et al. (1995), but with less statistical power (20 subjects per group), the difference was not significant. Furthermore, the social phobics had identical scores to the PD patients.

Barsky et al. (1994) studied three groups: two groups of patients who were referred to ECG monitoring for the evaluation of palpitations (groups with and without panic disorder), and a normal comparison group. Subjects were asked to record arrhythmias in a diary and these recordings were compared with a continuous (24 h) ECG monitoring. They were also asked to estimate the number of heartbeats at two predetermined 15 s intervals during the same day. Results showed that PD patients were more likely to describe their palpitations as 'racing' or 'pounding', but they did not have more cardiac arrhythmias, and their symptom reports were less likely to be due to cardiac irregularities. They were also not more accurately aware of their heartbeats than non-panic palpitation patients.

A relatively neglected question is whether the perceived heartbeats are indeed related to the actual heart rhythm. It should be noted that the performance of PD patients ($\pm 25\%$ error) is also not very good. Nevertheless, Ehlers et al. (1995) view their open instruction as a valid measure of heartbeat perception because of a previously reported significant correlation between stroke volume and performance on the heartbeat perception test (Schandry et al., 1993), and because almost all subjects (patients and controls) report fewer heartbeats than actually occur. Also, the test-retest reliability is adequate (Ehlers and Breuer, 1992). Ehlers et al. (1995) find it highly unlikely that

subjects reported heartbeats without corresponding sensation, and believe that subjects accurately count their heartbeats but miss a few. In pilot trials with a total of 70 normal subjects, however, we found that (on questioning) subjects typically reported not having missed a few beats, but instead having felt a regular rhythm somewhat slower than the actual rhythm. This makes it uncertain whether the perceived rhythm has anything to do with actual heartbeats. In other words, the test may not be valid. If, hypothetically, PD patients feel more nervous during the test, they may expect and count a faster heartbeat rhythm than normals. They would then end with a lower error score, just because almost all subjects underestimate their heart rates. Alternatively, the lower error scores of PD patients may be caused by a small number of patients who accurately perceive their heartbeats (i.e. who have a 0% error score). It seems therefore necessary to look at individual test performance and decide whether a subject is an accurate perceiver. Ehlers and Breuer (1992) actually did this, and found more accurate perceivers among PD patients (37.5%) than among normal controls (19.6%). However, this was not considered a fruitful approach, because in subsequent analyses and publications only the continuous measure (% error) was used.

Another as yet ignored problem with the Ehlers et al. (1995) study has to do with confidence ratings that patients made after each trial (on a 0–10 scale). These confidence ratings for the standard instruction and the strict instruction were equivalent (around 5.8), which suggests at least that the subjects did not follow the strict instruction.

The fact that a clinically relevant finding (prediction of relapses) was reported with the standard instruction (Ehlers, 1995) makes it interesting to investigate what is actually measured. The present study was designed to investigate this. The hypothesis was tested that the heartbeat perception test with standard instruction is not a valid measure of heartbeat rhythm, but that the results are artifacts of another function, probably arousal. Subjects were asked to count their heartbeats while their heart rate and skin conductance level were being registered simultaneously. Questionnaires were administered measuring anxiety and depressive symptomatology, the cognitions associated with panic, and arousal

during the procedure. A normal and psychiatric comparison group were also tested.

2. Method

2.1. Subjects

Patients were consecutive psychiatric outpatients, with either a primary diagnosis of panic disorder (PD group) or major depression or dysthymia (MD group). Exclusion criterion for the PD group was current co-morbidity of a mood disorder, and for the MD group current co-morbidity of an anxiety disorder. A control group (NC) was recruited through an advertisement in a local newspaper. Excluded from all three groups were subjects with a history of psychosis (lifetime) or substance abuse within the past 6 months. Age limits were 18–70 years. The NC group received \$15 for their participation. All subjects gave informed consent to participate.

2.2. Instruments

2.2.1. Diagnosis

The criteria of the fourth edition of the Diagnostic and Statistical Manual (DSM-IV) (American Psychiatric Association, 1994) were used. The diagnoses were made by the treating physician, an advanced (third or fourth year) resident in psychiatry, in consensus with a supervising psychiatrist. With seven patients, the first author conducted a structured interview (Anxiety Disorders Interview Schedule, Revised, Di Nardo and Barlow, 1988), because there was some doubt on the diagnosis (the interview was adapted to DSM-IV criteria). One PD patient was excluded after this interview because of co-morbidity. No diagnostic interviews were conducted with the NC group; the advertisement asked for subjects who had never been treated and were not considering seeking treatment for psychiatric or psychological problems.

2.2.2. Heartbeat perception test

Heartbeat perception was assessed with the mental-tracking procedure (Schandry, 1981). Subjects were instructed to silently count their heartbeats during signalled intervals of 35, 25 and 45 s without

taking their pulse. Subjects had to take their watches off, and the length of the intervals was unknown to the subjects. The 'standard instruction' was used, which is: 'please count all the heartbeats you feel in your body'. The choice for this procedure and instruction lies in the fact that only with this combination, significant differences between PD patients and others have been reported (Ehlers et al., 1995). The beginning and end of each trial were determined as follows. Subjects were asked to concentrate on their heartbeats. After 10–15 s, the experimenter, who sat behind the subject with a stopwatch, said 'Start', and then 'Stop' at the end of the interval. The beginning and end of each trial were also signalled by pressing an 'event button' on the heart rate monitor. This procedure is less precise than the procedure of Ehlers et al. (1995), where the start and stop signals were determined by a computer on the basis of the ECG, but probably as precise as those used by other authors, e.g. the Barsky et al. (1994) ambulatory monitoring procedure. Immediately after the three trials, subjects were questioned by the experimenter and asked to say whether they had felt a regular heartbeat rhythm, whether they thought they felt all heartbeats or missed one or more beats; in the latter case, whether they had counted the missed beats; and, if missed beats were not counted, how many beats they thought they missed.

2.2.3. Apparatus

A heart rate and galvanic skin conductance level monitor was used (AMS31), developed by the Department of Psychophysiology, VU University Amsterdam (Klaver et al., 1993). Skin conductance was measured at intervals of 1 ms. Heart-rate was measured every 10 s. Pre-gelled, disposable silver chloride electrodes were used (Medtronic). For heart rate one electrode was placed at the ninth rib left, and one at mid-sternum. The two electrodes for measuring skin conductance (SC) were placed on the third finger and on the palm of the non-dominant hand.

2.3. Questionnaires

State-Trait Anxiety Inventory (STAI) (Spielberger et al., 1970): The Dutch version (Van der Ploeg et al., 1980) of the STAI was used to measure anxiety

disposition and state anxiety. Both subscales have a 20–80 score range.

Body Sensations Questionnaire (BSQ) and Agoraphobic Cognitions Questionnaire (ACQ) (Chambless et al., 1984; Arrindell, 1993): The BSQ consists of two 17 item scales. Subjects are requested to indicate how often they experience each of 17 body sensations associated with panic (e.g. 'palpitations', 'dizziness'), and how frightened they are when these sensations occur. Both scales have a 17–85 score range. The ACQ measures the tendency to have catastrophic thoughts while being nervous or anxious (e.g. 'I will faint', 'I'm having a heart attack'). The score range is 14–70.

Anxiety Sensitivity Index (ASI) (Peterson and Reiss, 1992): This is a 16 item self-report measure of the fear of anxiety symptoms. It measures the beliefs about the harmfulness of bodily sensations (McNally, 1994). It can be considered a combination of the BSQ ('fear of' scale), e.g. 'It scares me when I feel faint', and the ACQ, e.g. 'When I notice my heart is beating rapidly, I worry that I might have a heart attack'. Psychometric data nevertheless suggest that it measures a single factor (McNally, 1994). The score range is 0–64.

Positive and Negative Affect Scale (PANAS) (Watson et al., 1988): The PANAS consists of two 10 item scales. The Positive Affect (PA) scale measures 'the extent to which a person avows a zest for life' (Watson and Tellegen, 1985) and includes items such as 'interested' and 'alert'. Negative Affect (NA) is 'the extent to which a person reports feeling upset or unpleasantly aroused'. Scale items include 'distressed' and 'nervous'. The state version ('at the present moment') was used.

Somatosensory Amplification Scale (SSAS) (Barsky et al., 1990): The Dutch version (Speckens et al., 1996) of the 10 item SSAS was used to assess the tendency to experience somatic sensations such as intense, noxious and disturbing.

Self-rating Depression Scale (SDS) (Zung, 1965): The 20 item SDS was used to measure depressive symptomatology (Dutch version by Dijkstra, 1974)).

The scales for which no Dutch version was available (ASI and PANAS) were translated (and translated back for checking) with the help of two native English speakers.

2.4. Procedure

Subjects were tested individually in a single session. For the test day, subjects were asked to abstain from alcohol, to eat just a light meal, and not to smoke or drink (caffeine) more than usual. The first part of the session, which lasted about 40 min, concerned several information processing tests that are not reported here. After a short break, electrodes were placed. After about 20 min of adaptation for the skin conductance recording (during which subjects filled out the questionnaires), the three heartbeat perception trials were carried out, with a 2 min interval. During these intervals, subjects performed a neutral distraction task, in order to refocus their attention away from their bodily sensations: they were given an incomprehensible (Italian or Swedish) text and were asked to circle two letters (m and p) each time these letters occurred in the text. After the heartbeat trials, subjects did a number of tests that are also not reported here. However, the final trial of these tests was a rather stressful task (maximum breath-holding duration after maximal inhalation), and could therefore be used to assess the maximum skin conductance level for each subject. The range of skin conductance level (maximum–baseline level) was used to calculate the relative level of arousal during the heartbeat perception trials. This procedure is known as range correction (Lykken, 1972). The formula is as follows: $\text{relative level} = (\text{actual level} - \text{minimum level}) / (\text{maximum} - \text{minimum level})$.

2.5. Data processing

Heartbeat perception error was calculated as follows: the absolute value of perceived heartbeats minus actual heartbeats was divided by actual heartbeats. This was then multiplied by 100, resulting in a percentage error score. Two other measures were calculated in the present study: a corrected heartbeat perception error score and a dichotomous score for accurate/non-accurate perceiving. For the corrected error score, the number of reported beats was supplemented by the estimated number of missed beats, if any. An error margin of three beats per trial was allowed to determine whether a subject was an accurate perceiver. Corrected perception scores were

used for this. Subjects were considered accurate perceivers if they consistently counted the correct number of heartbeats over the three trials, or over two of the three trials in the event that the third trial failed (i.e. the subject felt nothing during one of the trials). This latter possibility applied to two subjects.

2.6. Data analysis

Prior to analysis, the data were examined for accuracy of data entry, missing values and normality of distributions, following the recommendations by Tabachnick and Fidell (1989). One case with an extremely high z -score on actual heart rate was a univariate outlier. This case was left out of the analyses that involved actual heart rates. There were three missing values on the SC level: with two Ss the electrodes became detached and the data of one subject were unretrievable due to a software problem. Between-group differences were examined with oneway analysis of variance and LSD contrasts (or

X^2 tests when appropriate). Pearson correlations and multiple regression analyses were used to calculate the relationships among actual and perceived heart rates, psychological test scores and physiological data.

3. Results

3.1. Preliminary analyses

A description of the three groups in terms of demographic variables and psychological test scores is given in Table 1.

Age and sex distribution were equivalent among groups. The normal control group differed significantly from both patient groups on each of the psychological test scores. So, although the normal controls were not systematically evaluated for psychiatric disorders, as a group they were clearly different from the two patient samples. The PD

Table 1
Patient and control samples

	NC (<i>N</i> = 21)	PD (<i>N</i> = 23)	MD (<i>N</i> = 16)	<i>F</i> (57,2)	<i>p</i> -value
Age (years)	44.5 (14.1)	41.1 (10.6)	40.4 (13.0)	0.61	ns
Sex (% male)	38.1	34.8	18.8	$X^2 = 1.7$; <i>df</i> = 2; ns	
Anxiety sensitivity index	7.5 ^a (6.6)	28.7 ^c (11.0)	21.9 ^b (12.0)	25.4	< 0.0001
Agoraphobic cognitions quest.	17.3 ^a (5.5)	27.1 ^b (10.4)	22.8 ^b (5.8)	8.6	0.0006
Body sensations quest. (fear of)	23.7 ^a (7.7)	39.9 ^b (14.1)	33.9 ^b (12.2)	10.7	0.0001
Body sensations quest. (frequency)	22.3 ^a (5.9)	43.1 ^c (11.5)	36.4 ^b (9.9)	27.3	< 0.0001
Somatosensory amplification scale	9.6 ^a (4.7)	16.5 ^b (5.1)	13.6 ^b (5.9)	9.7	0.0002
PANAS: negative affect	11.1 ^a (1.4)	17.3 ^b (5.8)	19.6 ^b (9.3)	9.9	0.0002
PANAS: positive affect	34.6 ^c (7.7)	27.0 ^b (6.2)	22.2 ^a (7.0)	14.8	< 0.0001
STAI: state anxiety	29.5 ^a (5.9)	43.7 ^b (9.4)	50.4 ^c (13.2)	23.7	< 0.0001
STAI: trait anxiety	33.4 ^a (7.2)	52.4 ^b (9.9)	58.6 ^c (9.9)	41.0	< 0.0001
SDS (depressive symptoms)	33.8 ^a (7.1)	48.1 ^b (7.0)	54.0 ^c (5.9)	45.4	< 0.0001

Means with different suffixes (a,b,c) differ significantly at $p < 0.05$.

group scored higher than the MD group on the ASI, the BSQ ('frequency'-scale), and the PA-scale. The patient groups had equivalent scores on the ACQ, the BSQ ('fear of'-scale), the SSAS and the NA-scale (there were non-significant differences in the expected direction). The MD group had higher SDS scores, but also higher STAI scores (despite the exclusion of patients with current anxiety disorders). Perhaps due to the exclusion of patients with a current mood disorder, the PD group seems to score a little bit lower than expected on several questionnaires, e.g. the ASI [28.7, as compared with 32.8 in a Spanish study (Sandin et al., 1996)]. The normal controls' ASI score (7.5) is much lower than that reported by the authors of the test (19) (McNally, 1994), but comparable to the mean score in the Spanish study (8.2).

3.2. Reliability of the heartbeat perception test

To determine the reliability of the heartbeat perception test, correlation coefficients among the three trials were calculated. The correlations were significant ($p < 0.001$) and reasonably high (average $r = 0.77$; range: 0.66–0.84). Moreover, the correlations were satisfactory within each experimental group: NC: average $r = 0.81$ (range: 0.72–0.92); PD: average $r = 0.84$ (range: 0.79–0.85); MD: average $r = 0.84$ (range: 0.71–0.93).

3.3. Results of the heartbeat perception test

The results of the heartbeat perception test are shown in Table 2. The mean error scores for PD patients and controls are 30.3 and 37.1%, respectively, which is consistent with Ehlers et al. (1995) and Antony et al. (1995). The MD patients underestimate their heart rate by 42.7% (comparable to Ehlers and Breuer, 1992). With corrected error scores the PD patients score 25.8%, while the NC and MD group score 33% and 41.3%, respectively. The latter two groups have more subjects who could not feel any heartbeat ('non-responders'). Five subjects (2 NC, 1 PD, 2 MD) were 'partial-responders': they felt heartbeats in only one or two of the three trials.

Next, all perceived and actual heartbeats were compared for each subject individually. It appeared that nine subjects (7 PD, 2 NC, 0 MD) were accurate perceivers. The distribution of accurate perceivers among groups was significantly different. One-by-one comparisons showed a significantly higher proportion of accurate perceivers among the PD group than among the MD group, and a trend ($p = 0.09$) for the difference between PD and NC. The nine accurate perceivers had significantly higher scores on the questionnaires measuring the cognitions associated with panic: ASI and ACQ [and on the BSQ ('frequency' scale)]. For instance, on the ASI the mean scores were 27.9 (S.D. = 17.7) and 18.0

Table 2
Heart rate and heart rate perception per group: means (standard deviations)

	NC (<i>N</i> = 21)	PD (<i>N</i> = 23)	MD (<i>N</i> = 16)	
Heart rate (baseline)	71.8 (19.7)	71.5 (7.2)	71.4 (10.6)	$F(55,2) = 0.0$; ns
Heart rate (during trials)	66.4 (9.7)	72.2 (18.7)	70.7 (14.7)	$F(55,2) = 0.9$; ns
Error rate (%)	37.1 (22.9)	30.3 (26.8)	42.7 (22.4)	$F(45,2) = 0.9$; ns
Corrected error rate (%)	33.0 (23.6)	25.8 (22.2)	41.3 (22.4)	$F(45,2) = 1.7$; ns
% non-responders	23.8*	4.3 ^a	37.5 ^b	$\chi^2(2) = 6.8$; $p = 0.03$
% accurate perceivers	9.5**	30.4 ^a	0.0 ^b	$\chi^2(2) = 7.6$; $p = 0.02$
After exclusion of accurate perceivers:				
Corrected error rate (%)	37.5 (21.8)	33.9 (22.3)	41.3 (22.4)	$F(36,2) = 0.3$; ns

Means with different suffixes (a,b) differ significantly at $p < 0.05$.

* Difference between PD and NC group: $p = 0.06$.

**Difference between PD and NC group: $p = 0.09$.

(S.D. = 12.3), respectively [$t(58) = 2.08$; $p = 0.04$]. There were no significant differences in age, actual heartbeats and scores on any other psychological test.

3.4. Determinants of perceived heart rate

For the non-accurate perceivers, the hypothesis was that the perceived heart rate has nothing to do with the actual heart rate. This hypothesis was confirmed by the absence of a correlation between actual and perceived heartbeats ($r = 0.15$ ns). That this was not an unlikely hypothesis is further illustrated in Fig. 1, which shows the heart rate and skin conductance data for an extreme case, a female PD patient who reacted very strongly in physiological

terms to the task of monitoring heartbeats. During the three trials (indicated by a black bar at the bottom of the graphs), actual heart rate jumped from approximately 70 to 150 beats/min, and skin conductance also increased. The perceived heart rates for this subject were 74, 79 and 72, the actual heart rates were 150, 150 and 148. No anxiety was reported by this subject. One of the MD patients had a similar pattern (not shown): his heart rate jumped to 149 beats during the first trial, but remained stable at 60 beats during trials 2 and 3. The corresponding perceived heart rates were 45, 0 and 0. Another female PD subject experienced a limited panic attack shortly after the third trial, which was accompanied by a marked increase in SC, but by no apparent change in heart rate. Her actual heart rates were 59,

Fig. 1. Heart rate (beats/min) and skin conductance level (μ S) of a PD patient during the three heartbeat perception trials (indicated by a black bar at the bottom of the graph).

60 and 56 and the corresponding perceived rates were 51, 41 and 40.

To investigate the factors that influence heart rate perception for the non-accurate perceivers, Pearson correlations were calculated of perceived heart rate with each of the psychological test scores and with range-corrected skin conductance level during the trials. The correlations with psychological test scores are listed in Table 3. Excluded from these correlations were the subjects who did not perceive any heartbeat. The correlations were calculated both for the whole group and for the non-accurate perceivers only. In both instances, the highest correlations were found with the two scales that measure arousal: Negative Affectivity (NA) and State Anxiety. Only these two are significant if one would adjust significance levels for the high number of correlations calculated. NA was the only variable that contributed significantly in stepwise multiple regression analyses of perceived heart rate (both for the whole group and for non-accurate perceivers only) (entered in the analyses were State and Trait anxiety, Positive and Negative Affectivity, Anxiety Sensitivity and Agoraphobic Cognitions).

The influence of arousal on perceived heart rate was confirmed by the physiological data, although the correlations were lower. Skin conductance levels during trials was weakly associated with perceived heart rates. The correlations were significant during Trial 1 ($r = 0.29$; $p = 0.04$) and Trial 3 ($r = 0.38$;

$p = 0.02$) and almost significant during Trial 2: $r = 0.28$ ($p = 0.07$).

4. Discussion

The present study has shown that it makes sense to distinguish accurate from non-accurate perceivers when analysing the results of the heartbeat perception test. There are more accurate perceivers among patients with panic disorder than among patients with a mood disorder, while a trend exists when panic disorder patients are compared with normal controls. Furthermore, accurate perceivers can be distinguished from non-accurate perceivers by cognitive measures, suggesting that the division is not arbitrary: accurate perceivers have higher anxiety sensitivity scores and a higher tendency to have catastrophic cognitions. They also report more frequent bodily sensations. For the non-accurate perceivers, perceived heart rate is unrelated to actual heart rate and cognitive factors, but significantly correlated with self-reported arousal and, to a lesser extent, with skin conductance levels during the trials. To summarize, more accurate perception of heartbeats by patients with panic disorder is a fact, because there is a higher number of accurate perceivers among PD patients. However, it is also an artefact, because the majority are inaccurate perceivers, and for these subjects, there is no correlation between

Table 3
Pearson correlations of perceived heart rate with psychological test scores

	Non-accurate perceivers ($N = 39$)	Whole group ($N = 48$)
Age	0.17	0.11
Anxiety sensitivity index	0.20	0.27*
Agoraphobic cognitions questionnaire	0.16	0.24*
Body sensations questionnaire (fear of)	0.10	0.20
Body sensations questionnaire (frequency)	0.06	0.14
Somatosensory amplification scale	-0.15	-0.07
PANAS: negative affect	0.56***	0.49***
PANAS: positive affect	-0.34	-0.28*
STAI: state anxiety	0.50***	0.47***
STAI: trait anxiety	0.32*	0.33*
SDS (depressive symptoms)	0.20	0.21

Notes: One-tailed significance: * $p < 0.05$; *** $p < 0.001$.

Omitted from the analyses were the subjects who could not feel any heartbeat.

actual and perceived heart rates. In this respect, it is important to add that the somatosensory amplification scale, which measures the tendency to selectively attend to relatively weak bodily sensations, failed to correlate with accuracy of perception or with the number of perceived heartbeats. In other words, people who subjectively report more or stronger bodily sensations do not perform better on an objective test (see also Barsky et al., 1995).

The present study suggests that the level of arousal influences the perceived heart rates of non-accurate perceivers, with higher arousal co-occurring with a higher number of perceived heartbeats. However, the correlations with self-reported arousal were higher than the correlations with the more direct psychophysiological measures. It is important to note that our recordings may have failed to detect the most relevant factors. Instead of mean SC level it may have been better to use the number of SC fluctuations occurring during the trials as compared with the baseline. With the apparatus used, this was not possible. Therefore, a replication of this study with more sophisticated skin conductance recordings seems warranted. Furthermore, it is self-evident, but still important to note, that the relationship between arousal and heartbeat perception is correlational. The direction of causality can only be investigated through studies in which the level of arousal is manipulated experimentally.

The possibility should be considered that suggestion and suggestibility play an important part in the heartbeat perception test. The test requires subjects to focus their attention and to direct their attention inwards, which is also characteristic of many hypnotic induction procedures (Hilgard, 1965). Many subjects were surprised to find out that they were actually able to feel a heartbeat rhythm.

A limitation of the present study lies in the fact that we relied on self-selection and not on standardized diagnostic assessments in recruiting the normal control sample. Given the relatively small number of subjects in the study, and the high prevalence of affective disorders in the general population, this may have influenced the results. However, as a group the controls were clearly different from both patient groups on all questionnaires.

Relevant questions for future studies include the

following. It would be interesting to see whether the confidence ratings, as used by Ehlers et al. (1995) are different for accurate and non-accurate perceivers. Furthermore, is the predictive value of a low error score for relapse (Ehlers, 1995) mediated by cognitive or affective factors? In other words, is the prediction caused by the fact that patients with low error scores are accurate perceivers (who have higher anxiety sensitivity scores) or by the fact that they are non-accurate perceivers with higher arousal scores? Finally, it would be interesting to see whether physical exercise, which improves mean accuracy scores (Antony et al., 1995), does so by improving the ratio of accurate/non-accurate perceivers or by raising the arousal level of non-accurate perceivers. In fact, these questions may be answered by these authors with their available data.

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