Available online at www.sciencedirect.com
ScienceDirect
Behaviour Research and Therapy 45 (2007) 1921–1930
BEHAVIOUR RESEARCH AND THERAPY
www.elsevier.com/locate/brat

Shorter communication

Heartbeat perception in depression

Barnaby D. Dunn[a,*], Tim Dalgleish[a], Alan D. Ogilvie[b], Andrew D. Lawrence[a]

[a]Medical Research Council Cognition and Brain Sciences Unit, 15 Chaucer Road, Cambridge, CB2 2EF, UK
[b]University of Oxford Department of Psychiatry, Warneford Hospital, Oxford, OX3 7JX, UK

Received 4 April 2006; received in revised form 24 August 2006; accepted 7 September 2006

Abstract

Alterations in bodily awareness have been implicated in depression but there has been little detailed empirical characterisation of the degree and accuracy of body perception in the disorder. The present study examined the objective accuracy of heartbeat perception (using the Schandry mental tracking task) and the subjective degree of bodily focus (using the Bodily Consciousness Questionnaire; BCQ) in healthy control volunteers, a moderately depressed community sample, and a more severely depressed clinic sample ($n = 18$ in each group). The community sample showed less accurate heartbeat perception than the control group as expected. Counter to prediction, however, the more severely depressed clinic sample performed better than the community depressed sample and equivalently to control volunteers on the Schandry task. There were no group differences on subjective bodily awareness. Implications for theories of depression are discussed.

Keywords: Depression; Emotion; Interoception; Heartbeat perception; Cardiac perception; Body

Introduction

There is a long tradition arguing that perception of bodily activity can shape emotion and cognition. Peripheral feedback theories (e.g. James, 1884) famously and controversially proposed that emotion experience arises directly from the perception of bodily change: ‘‘We feel sorry because we cry, angry because we strike, afraid because we tremble’’ (James, 1884, p. 190). More recently, the somatic marker hypothesis (Damasio, 1994) argued that emotional biasing signals arising from the body help regulate decision-making. These accounts predict that the more aware people are of bodily activity, the more intensely they should experience emotions and the better able they should be to make decisions.

While support for these theories is mixed (Dunn, Dalgleish & Lawrence, 2006; Prinz, 2004), it remains plausible that altered feedback from the body could be an important contributing factor to the onset and maintenance of psychopathology. In particular, depressed states lead to a range of bodily changes, including appetite, sleep, energy and libido changes and an increase in aches and pains (DSM-IV; APA, 1994), and these symptoms make a significant contribution to the felt burden of the condition (Tylee & Gandhi, 2005). Somatic symptoms appear to be the most ubiquitous feature of depression across cultures (Kirmayer, 2001) and it has been argued that many

*Corresponding author. Tel.: +44 1223 355294x291; fax: +44 1223 359062.
E-mail addresses: barney.dunn@mrc-cbu.cam.ac.uk (B.D. Dunn), tim.dalgleish@mrc-cbu.cam.ac.uk (T. Dalgleish), alan.ogilvie@psychiatry.ox.ac.uk (A.D. Ogilvie), andrew.lawrence@mrc-cbu.cam.ac.uk (A.D. Lawrence).

0005-7967/$ - see front matter
doi:10.1016/j.brat.2006.09.008

phrases used in contemporary culture to describe the psychological experience of dysphoria (e.g. 'broken hearted') are extensions of what were originally 'somatic expressions' (Beeman, 1985). Empirical studies confirm that systems regulating the body are disturbed in depression, including a hypo-responsive autonomic nervous system (e.g. Dawson, Schell, & Catania, 1977) and a dysregulated hypothalamic pituitary adrenal axis (Plotsky, Owens, & Nemeroff, 1998). It is possible that feedback of these somatic alterations could influence both emotion and cognition (e.g. anhedonia and impaired everyday decision-making) in depression.

Traditional accounts of depression have neglected somatic symptoms (e.g. Beck's (1967) cognitive model) but some recent frameworks have begun to articulate a role for bodily feedback in the disorder. For example, Interacting Cognitive Subsystems (ICS; Teasdale & Barnard, 1993) proposes that depressive negative schematic models are maintained by two interconnected sources of information: cognitive feedback from a propositional (or thought like) level of representation; and, sensory feedback from a bodily level of representation. ICS is silent however about exactly how activity or awareness of the body is altered in depression and there is a shortage of empirical evidence on this important issue.

In contrast to the paucity of research in depression, bodily awareness in anxiety has received considerable attention. Influential cognitive models of panic disorder (e.g. Clark, 1986) argue that panic attacks arise from hyper-vigilance to and misattribution of physiological arousal (e.g. increased heart rate meaning a heart attack is imminent). A range of studies have measured cardiovascular perception accuracy in anxiety disorders (e.g. Ehlers & Breuer, 1992) and the general conclusion reached is that a small but significant proportion of individuals with panic disorder show elevated interoceptive accuracy (Ehlers & Breuer, 1996; Van-der-Does, Antony, Ehlers, & Barsky, 2000).

Given the known link between cardiac abnormalities and depression (e.g. Musselman & Nemeroff, 2000) and the extensive database gathered on anxiety disorders, heartbeat perception also seems a logical place to begin examining bodily awareness in depressed states. There has however been limited empirical examination of heartbeat perception in depression using such methodologies. As far as we are aware, three studies report data of depressed participants on heartbeat perception tasks, typically as psychiatric control groups in studies primarily targeting panic disorder (Ehlers & Breuer, 1992; Mussgay, Klinkenberg & Ruddel, 1999; Van-der-Does, Van-Dyck, & Spinhoven, 1997). These studies found a subtle but non-significant trend for heartbeat perception to be less accurate in depressed individuals relative to control volunteers, although small sample sizes, a lack of direct comparison between control and depressed samples, and/or inclusion of individuals with mild or comorbid presentations of depression make this conclusion preliminary.

The typical finding in experimental studies in other domains is a small impairment in mild depression or dysphoria which becomes significantly more marked in clinical depression (the 'continuity hypothesis'; Flett, Vredenberg, & Krames, 1997). It is therefore possible that a significant heartbeat perception deficit would have emerged if a larger sample of more severely depressed individuals with low levels of comorbidity had been recruited.

Moreover, no previous study examined the relationship between the degree to which depressed individuals habitually attend to the body and the accuracy with which they can monitor the body. An implicit assumption in much of the self-monitoring literature is that the more people tend to focus attention to internal experience, the more accurately they will be able to monitor this experience (the 'perceptual accuracy hypothesis'; Silvia & Gendolla, 2001). Specifically, there is some evidence to suggest that experimental manipulations of self-focus (e.g. looking at oneself in a mirror) can improve some measures of the accuracy of heartbeat perception (Weisz, Balazs, & Adam, 1988). Whether or not the perceptual accuracy hypothesis holds for awareness of the body in depression has yet to be examined.

Given the limited database there is a need for further exploration of heartbeat perception in depression, taking into account the possible influence of symptom severity and considering the relationship between task accuracy and degree of bodily focused attention. In the present study we therefore decided to systematically examine both the *extent* and *accuracy* of body perception in depressed states. Cardiovascular perception was measured on the Schandry mental tracking paradigm (cf. Ehlers & Breuer, 1992) and this was related to a self-report measure of the habitual tendency to focus attention on the body (the Body Consciousness Questionnaire [BCQ]; Miller, Murphy, & Buss, 1981), in healthy control participants, a group of participants reporting moderate depressive symptoms recruited from the community, and a more severely depressed group of individuals formally diagnosed with Major Depressive Disorder (with low levels of co-morbidity) recruited from the clinic.

We predicted that both depressed groups would report reduced subjective awareness of the body and show less accurate heartbeat perception (cf. Ehlers & Breuer, 1992), relative to the control group, with these deficits becoming more marked with increasing symptom severity. Further, we hypothesised that there would be a positive correlation between subjective awareness of body-state and objective heartbeat perception accuracy across all participants (cf. the perceptual accuracy hypothesis; Silvia & Gendolla, 1992).

Method

Participants

All participants were between 18 and 65 yr of age and had no history of brain injury, psychosis, learning disability, or substance abuse problems (screened using a semi-structured interview).

Eighteen people with a Beck Depression Inventory (BDI; Beck, Ward, Mendelson, Mock, & Erbaugh (1961)) score greater than 15 (“moderately to severely depressed”; Shaw, Vallis, & McCabe, 1985) recruited via advertisement in a local newspaper comprised the community depressed group. Seven had been diagnosed with clinical depression by their general practitioners and were taking Selective Serotonin Reuptake Inhibitors (SSRIs). One other participant was taking St John’s Wort.

Eighteen people diagnosed with current major depressive disorder (MDD) according to the Diagnostic and Statistical Manual for Mental Disorders (DSM-IV; American Psychiatric Association APA, 1994) recruited from a psychiatric clinic (the Fermoy Unit, Kings Lynn, UK) constituted the clinic depressed group. MDD diagnosis was ascertained using the Structured Clinical Interview for the DSM-IV (SCID; First, Spitzer, Gibbon, & Williams, 1994). In addition, patients were excluded if they had a comorbid diagnosis of Panic Disorder, since this has previously been shown to influence body-perception accuracy (cf. Ehlers & Breuer, 1992). Seventeen individuals were outpatients and one was an inpatient. Eight participants had a pure diagnosis of MDD (all female) and 10 participants had MDD with marked anxiety symptoms (5 females; 5 males). All patients were using anti-depressant medication, either SSRIs alone ($n = 14$) or SSRIs in combination with anxiolytics and hypnotics ($n = 4$). The sample was moderately to severely depressed, as measured by the 21-item Hamilton Depression Rating Scale (HDRS, Hamilton, 1960), Mean = 21.32; SD = 4.22. All participants were tested within two weeks of diagnostic assessment.

Eighteen people with a BDI score less than 10 (“non-depressed”; Shaw et al., 1985) and not reporting a current diagnosis of depression were recruited from the MRC Cognition and Brain Sciences Unit participant panel into the control group. One participant was medicated (thyroxine).

The groups were comparable for age, gender and estimated IQ according to the National Adult Reading Test (NART; Nelson, 1982) (see Table 1). The study was approved by local research ethics committees and all participants provided written informed consent. The community depressed and control groups were given an honorarium of £5 per hour for participating. Clinic depressed participants had their travel expenses fully reimbursed but were not given an hourly honorarium, in line with local ethics committee procedures.

Body perception task

Body-perception accuracy was measured using the amended version of the Schandry (1981) heartbeat perception task, as described by Ehlers & Breuer (1992).[1] In brief, on each trial participants counted how many heartbeats they felt over a period of time, which was then compared to how many heartbeats were actually measured by electrocardiogram (ECG). To ensure heartbeat perception was not confounded with ability to estimate time, in a number of trials participants were asked to estimate how many seconds passed

[1]There is some controversy about whether the Schandry task is best interpreted using continuous (mean error score) or categorical (classifying participants as accurate perceivers if their error rate is lower than an arbitrary criterion) analysis methods (Van-der-Does et al., 1997; Ehlers, 1998). Ehlers (1998) argued that dichotomous scoring is only really appropriate in situations where a high proportion of participants show very poor performance (error rates > 70%) or where there is clear evidence of a bimodal performance distribution. Use of these analysis methods at other times unnecessarily reduces statistical power and can lead to a proportion of participants being erroneously classified as inaccurate perceivers if they miss a few more beats than specified by the criterion. Given that the data in the present study were not obviously bimodally distributed and included no participants showing extremely poor performance, we adopted a continuous analysis approach.

Table 1
Demographic and clinical characteristics of participants

Variable	Control ($n = 18$)	Community depressed ($n = 18$)	Clinic depressed ($n = 18$)
Age (in years)	44.8 (13.0)	40.1 (15.6)	47.1 (9.9)
NART Full Scale IQ	108.1 (6.5)	111.2 (9.0)	106.1 (12.5)
% Female	77.8%	72.2%	72.2%
BDI	4.3 (3.0)	22.2 (8.1)	28.3 (9.0)
STAI—State	28.4 (5.6)	48.3 (12.7)	57.9 (12.6)
STAI—Trait	33.6 (9.1)	60.1 (9.2)	63.8 (8.6)
BMI*	25.0 (5.7)	23.9 (3.0)	25.7 (4.9
Physical Activity	2.3 (0.7)	2.1 (0.8)	1.9 (0.8)
HR (beats per minute)+	76.1 (10.9)	77.8 (8.6)	73.1 (12.2)
HR variability (SDNN)	0.1 (0.0)	0.1 (0.0)	0.1 (0.0)
BCQ—private	14.2 (4.6)	16.3 (4.3)	16.5 (3.8)
BCQ—public	11.28 (3.5)	12.8 (4.9)	11.9 (5.4)
BCQ—competence	8.7 (3.0)	7.4 (3.2)	8.1 (3.0)

Note: Data are mean (standard deviation) values. NART = National Adult Reading Test; BDI = Beck Depression Inventory; STAI = Spielberger State Trait Anxiety Inventory; BMI = body mass index; HR = heart rate; SDNN = standard deviation of heart rate interval; BCQ = Body Consciousness Questionnaire. * BMI data were not available for two participants in the clinic depressed group and one participant in each of the other two groups. + One participants' HR mean and variability data in both the community and depressed group were lost due to equipment failure.

over varying time intervals. Participants completed three heartbeat trials (1×35, 2×25 and 1×45 s), three time trials (1×23, 1×56 and 1×40 s) and then three heartbeat trials (1×23, 1×56 and 1×40 s) in a fixed sequence (see Ehlers & Breuer, 1992 for full details). Prior to testing, participants were asked to remove their watch and instructed not to take their pulse with their fingers or to hold their breath.

Heart rate was recorded used a BIOPAC™ MP100 unit and an ECG 100B amplifier acquiring data at 200 samples per second, connected to a second Pentium 300 computer running Acqknowledge 7.0 software (BIOPAC, 1997).

Time and heartbeat perception inaccuracy was calculated by taking the modulus of the actual value minus the estimated value, dividing this by the actual value, and then multiplying by 100 to express the inaccuracy as a percentage ($[|\text{actual}-\text{estimated}| \div \text{actual}] \times 100$). Mean error scores were calculated for the three trials in each task block (cf. Ehlers & Breuer, 1992; Schandry, 1981) (See footnote 1).

To check that group differences in heartbeat perception were not an artefact of variations in resting heart rate, mean heart rate and heart rate variability (standard deviation of the interbeat interval; SDNN) during a three minute rest task prior to the experiment were recorded for each participant.

Self-reported awareness of body-state

The Body-Consciousness Questionnaire (BCQ; Miller et al., 1981) was used to index self-awareness of body-state. Participants self rate to what extent 15 statements about bodily awareness are characteristic of them (e.g. "I am sensitive to internal bodily tensions"), on a five-point scale from 0 (not at all characteristic) to 5 (extremely characteristic). The BCQ measures three facets of bodily awareness: private body-consciousness is attention to internal bodily sensations (6 items, maximum total score 24), public body-consciousness is focus on observable aspects of the body (6 items, maximum total score 20), and body competence is the perceived efficacy of bodily actions (4 items, maximum total score 16).[2]

[2]We selected the BCQ to measure subjective bodily awareness as it has been extensively used in previous interoception studies in both healthy (e.g. Weisz et al., 1988) and clinical populations (e.g. Christensen, Wiebe, Edwards, Michels, & Lawton, 1996). Further, it provides a general measure of bodily awareness rather than focusing more narrowly on panic-related cognitions about the body. It will be important for future research to examine the relationship between cardiac perception and other measures of subjective bodily awareness (for example, the Somatosensory Amplification Scale or the Body Sensations Questionnaire) in depression.

Procedure

Participants were screened, completed the BDI, the Spielberger State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) and the BCQ, along with other questionnaires not described here. Body Mass Index (BMI) and physical activity levels (rated on a seven-point scale as used by Ehlers & Breuer, 1992) were also measured, as these factors have been shown to influence interoceptive awareness. The psychophysiology electrodes were then attached and volunteers performed the rest task followed by the body-perception task, as well as other experimental tasks not reported here. Testing took place in a quiet, softly lit room, with participants seated in a comfortable chair facing the computer monitor.

Results

Group comparison

Table 1 summarises the demographic characteristics of participants in the experimental groups. The groups significantly differed as planned on BDI, F (2, 54) = 54.10, $p < .01$ as well as on Spielberger state anxiety, F (2, 54) = 34.68, $p < .01$, and Spielberger trait anxiety, F (2, 54) = 61.03, $p < .01$, scales. Least significant difference (LSD) post hoc tests revealed that the two depressed groups showed higher scores than the control group on all the above measures (p's $< .01$). Further, the clinic depressed group showed higher scores than the community depressed group on BDI ($p = .01$) and Spielberger state anxiety ($p = .01$), but did not differ significantly on Spielberger trait anxiety ($p = .22$). There were no significant group differences for age, F (2, 54) = 1.34, $p = .27$, IQ, F (2, 54) = 1.24, $p = .30$, gender ratio, χ^2 (2) = .19, $p = .91$, physical activity, F (2, 54) = 1.53, $p = .23$, BMI, F (2, 50) < 1, mean resting heart rate, F (2, 52) < 1, or heart rate variability (SDNN), F (2, 52) < 1.[3]

Body consciousness questionnaire

There were no significant group differences for private, F (2, 54) = 1.72, $p = .27$, public, F (2, 54) < 1, or competence, F (2, 54) < 1, BCQ factors (see Table 1).

Body perception task

To analyse perception accuracy univariate ANOVAs compared groups on the mean error score on the time and heartbeat components of the task (see Fig. 1). These found a significant effect of group for heartbeat error, F (2, 54) = 7.64, $p < .01$. LSD post hoc tests revealed that the community depressed group had a greater error score than both the control group ($p < .01$; Cohen's d [Cohen, 1988] = .85) and the clinic depressed group ($p < .001$; Cohen's $d = 1.29$), but that there was no significant difference between the control and clinic depressed groups ($p = .33$, Cohen's $d = .40$). There was no significant group difference for time estimation error, F (2, 54) < 1.[4]

[3]While the community and clinic samples significantly differed from one another on depression scores, it is important to note there was some degree of symptom overlap. In particular, no upper BDI cut-off in the community sample was used and a number of participants in this group had been formally diagnosed with depression by medical professionals. The distribution of BDI scores can be observed in Fig. 2.

[4]A significant difference remained between the two depressed groups when covarying out Spielberger state and trait anxiety, F (3, 35) = 10.43, $p < .01$, suggesting the findings are not solely driven by variation in anxiety. The picture was less clear cut with medication status. A significant difference remained between the two depressed groups if medication status was covaried out, F (2, 35) = 14.57, $p < .01$. If all three groups were collapsed and then split on the basis of medication status (covarying out depression severity) there was however a significant effect of medication, F (2, 53) = 4.07, $p = .05$, with medicated individuals performing better on the task. These results suggest that there is a contribution of both depression severity and medication status to heartbeat perception accuracy. Participants also rated confidence in their heartbeat and time estimations. Since there were no clearly significant differences between groups (p's $> .05$), these confidence ratings are not reported here.

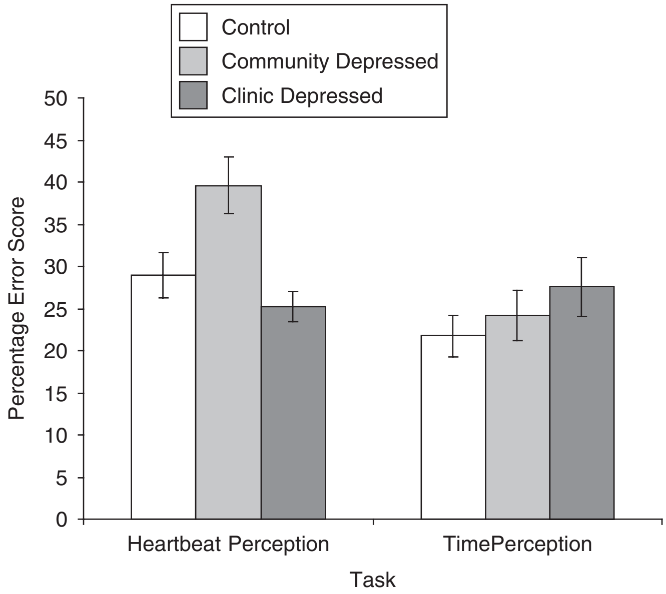

Fig. 1. Heartbeat perception and time perception error scores on the Schandry task. Data are mean (standard error of the mean) values.

Table 2
Pearson correlations between mean heartbeat perception error score and other variables

	Control ($n = 18$)	Community depressed ($n = 18$)	Clinic depressed ($n = 18$)	Combined ($n = 54$)
BCQ—private	−.01	−.37	−.09	−.13
BCQ—public	.24	−.11	.15	.09
BCQ—confidence	.20	.32	−.47	.03
BDI	.21	−.53*	.05	−.09
STAI—State	−.05	−.27	.27	−.06
STAI—Trait	.23	−.21	.25	.08
Time trial error score	.21	.20	.13	.12

Note: BCQ = Body Consciousness Questionnaire; BDI = Beck Depression Inventory; STAI = Spielberger State Trait Anxiety Inventory. * = correlation significant at $p < .05$.

Correlational analysis

Pearson's bivariate correlations were conducted in each group separately to examine the association between error scores on the heartbeat estimation trials with the BCQ factors and self-report of anxiety (STAI) and depression (BDI) symptoms (see Table 2). In the community depressed group there was a significant negative correlation between error score on the heartbeat trials and BDI ($r = -.53$, $p = .03$), indicating that as depression severity increased accuracy of heartbeat perception improved. No other correlations were significant in any of the groups (p's $> .05$), including the relationship between heartbeat error score and BDI in the clinic depressed group ($r = .05$, $p = .84$). Similarly, when pooling participants across groups ($n = 54$) to increase statistical power no significant correlations emerged.

Given that the group results showed that the body perception deficit found in moderate depression normalised in more severe cases of depression, we examined the data for any curvilinear relationships between heartbeat error score and BDI, STAI state and trait anxiety, and the BCQ factors by testing the fit of a quadratic function in a non-linear regression. Consistent with the findings from the group analysis, a significant curvilinear relationship emerged between BDI and heartbeat error score, $F\,(2, 51) = 3.65$, $p = .04$, $r^2 = .13$. As BDI scores increased from low to moderate levels, heartbeat error score increased. As BDI scores

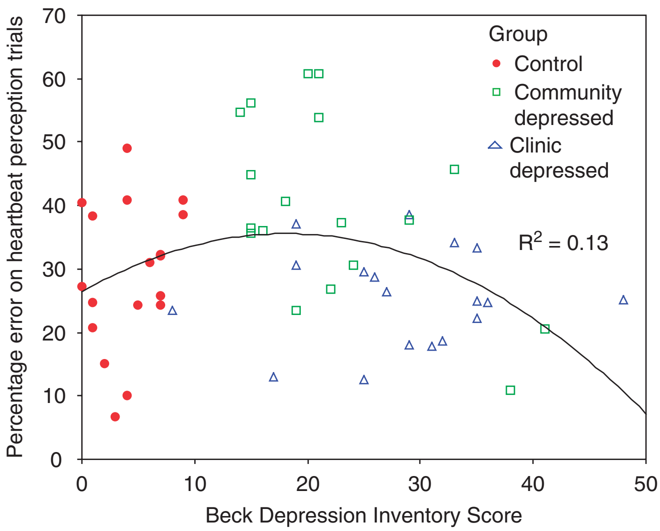

Fig. 2. Curvilinear relationship between BDI and error Score on heartbeat perception trials across all participants ($n = 54$). Curve = fitted regression line (R^2).

increased from moderate to high levels, heartbeat error scores decreased (see Fig. 2). All other non-linear regressions were non-significant (p's > .30).

Discussion

There has been a recent resurgence in theories arguing that bodily feedback can influence both emotion and decision-making (Damasio, 1994; Prinz, 2004). Given the prevalence and significance of somatic symptoms in depression (Tylee & Gandhi, 2005) and the fact that recent theories of the disorder have implicated a feedback role for body-state in maintenance of depressive schema (e.g. ICS; Teasdale & Barnard, 1993), it is of both theoretical and potentially clinical importance to empirically examine awareness of the body in the disorder.

The present study examined subjective, self-reported degree of awareness of the body and objective, cardiovascular perception accuracy in a moderately depressed community sample and a more severely depressed clinic sample as a preliminary investigation of this issue. We a priori predicted that both subjective self-report of bodily awareness and objective accuracy of cardiovascular perception would be impaired in depression and that this deficit would become more pronounced as symptom severity increased.

While the moderately depressed community group were found to be impaired on the heartbeat perception task relative to the control group as predicted, the more severely depressed clinic sample actually showed normal task performance. This failure to find support for our hypothesis that the clinic depressed group would be less accurate than normal controls is not due to lack of power in the study, as the clinic depressed group were numerically more accurate than controls on the task. Consistent with this unexpected pattern, non-linear regression analysis found that a quadratic curve significantly fitted the relationship between BDI and heart rate error scores across all participants. An increase from low to moderate depression severity resulted in *reduced* heartbeat perception accuracy, whereas an increase from moderate to high depression severity resulted in *increased* body perception accuracy.

There were no significant group difference in self-reported bodily awareness BCQ nor was there any significant relationship between BCQ and heartbeat perception accuracy in any of the groups. These null findings are unlikely to be due to limited statistical power, since a similarly non-significant pattern of results emerged when we repeated the correlational analysis and an additional linear and non-linear regression analysis on data pooled across participants in all three groups ($n = 54$).

The heartbeat perception accuracy differences found between moderate and more severe depression symptoms are unlikely to be an artefact of other confounding experimental variables known to influence cardiovascular awareness (cf. Ehlers & Breuer, 1992), since the groups were comparable for age, gender, intelligence, physical activity and BMI. Moreover, the groups did not differ in time estimation accuracy and there was no correlation between time and heartbeat error scores (see Table 2), suggesting that participants are not basing their heartbeat estimations on time perception. The clinic depressed group were significantly more anxious than the community depressed group. This difference cannot fully explain the present findings, however, since significant group differences remained when state and trait anxiety were covaried out of the analysis. This suggests that there is an effect of depression severity, over and above any anxiety influences, on heartbeat perception.

The deficit in heartbeat perception in moderate depression is consistent with the non-significant trends in the same direction found in earlier studies (e.g. Ehlers & Breuer, 1992; Van-der-Does et al., 1997; Mussgay et al., 1998) and suggests this pattern is relatively reliable and robust. As far as we are aware, our unexpected finding of unimpaired performance in the clinic depressed group is the first demonstration of a normalisation of this deficit in increasingly severe depression. Notably, Mussgay et al. (1999) also report a non-significant trend for 'neurotic' depressives to perform better on the task than 'reactive' depressives (classified according to ICD-9) and it is plausible, although untested, that this difference could be a function of symptom severity.

It will be important to replicate and extend these findings before drawing strong conclusions. Nevertheless, some provisional implications can be drawn. First, the data suggest that a complex relationship exists between depression and bodily awareness, at least as measured by the BCQ and heartbeat perception. In particular, blunted affect and impaired decision-making in depression are unlikely to be explained by reduced awareness of the body in the disorder (as might be predicted by a simplistic extension of peripheral feedback theories [e.g. James, 1884] to depression) and the complexity of this relationship, if replicated, will need to be incorporated into existing theoretical frameworks implicating bodily feedback in depression (e.g. ICS; Teasdale & Barnard, 1993). Second, the lack of a significant relationship between self-report measures and objective measures of bodily awareness tentatively suggests that the perceptual accuracy hypothesis (Silvia & Gendolla, 2001) does not hold in depression (see also Dunn, Dalgleish, Lawrence, & Ogilvie, in press), although it remains possible of course that a clearer relationship would emerge if state rather than trait measures of bodily awareness were used.

There are several limitations of the present study that need to be held in mind. First, the Schandry task has been criticised as a measure of cardiac perception, the suggestion being that it might be more influenced by beliefs held about heart rate than genuine interoceptive accuracy (e.g. Brener, Knapp, & Ring, 1995). While there is little reason to believe that the groups would hold different beliefs about underlying heart rate, it is nevertheless possible that group differences in beliefs may influence performance on the task. It will be important to replicate these results using other paradigms (e.g. the heartbeat detection task; Whitehead, Drescher, Heiman, & Blackwell, 1977).

Second, we have indexed only one aspect of bodily awareness. While the known link between cardiac problems and depression made cardiovascular perception a reasonable place to start, there are a range of other bodily symptoms of depression (including changes in energy levels, appetite, libido and muscle pains). A different profile may exist in depression when non-cardiac perception is examined.

Third, it is currently unclear whether it is symptom severity or medication status that is driving the normalisation of body perception accuracy in more severe cases of depression. Previous studies have generally found that medication does not reliably influence heartbeat perception accuracy (e.g. Mussgay et al., 1999), but these studies did not consider the specific effects of SSRIs on cardiac perception. It has recently been demonstrated that SSRIs reduce somatic symptoms of depression (Denninger et al., 2006) and it could be this that accounts for the normalisation of heartbeat perception in the medicated clinic sample in the present data. To test this possibility, it will be necessary to examine performance on the task of formally diagnosed but unmedicated patients with high levels of symptom severity.

In summary, moderate depression is characterised by a reduced ability to accurately perceive heartbeats, which appears to normalise in more severe depression. This result is interesting because it appears inconsistent with the 'continuity hypothesis' of depression (Flett et al., 1997), which assumes that deficits in dysphoria become more pronounced in clinical depression. Additional research is needed to clarify whether this finding is due to symptom severity or the effects of antidepressant medication and to see in what way, if any, alterations in bodily awareness relate to the emotional and cognitive symptoms of the disorder.

Acknowledgments

The UK Medical Research Council funded this study. We would like to thank Ruth Sumpter for help with conducting structured clinical interviews of depressed participants, Anke Ehlers for advice regarding use of the mental tracking task, and Phil Barnard for helpful discussions about ICS.

References

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders* (4th ed). Washington DC: American Psychiatric Association.

Beck, A. T. (1967). *Depression: Clinical, experimental, and theoretical aspects*. New York: Harper & Row.

Beck, A. T., Ward, C. H., Mendelson, M., Mock, J., & Erbaugh, J. (1961). An Inventory for measuring depression. *Archives of General Psychiatry*, *4*, 53–63.

Beeman, W. O. (1985). Dimensions of dysphoria: The view from linguistic anthropology. In A. Kleinman, & B. Good (Eds.), *Cross cultural psychiatry of affect and disorder* (pp. 216–243). Berkeley, CA: University of California Press.

BIOPAC. (1997). *BIOPAC MP100 Psychophysiological Data Acquisition System*. BIOPAC Systems, Inc.

Brener, J., Knapp, K., & Ring, C. (1995). The effects of manipulating beliefs about heart rate on the accuracy of heartbeat counting in the Schandry task. *Psychophysiology*, *32*(S22).

Christensen, A. J., Wiebe, J. S., Edwards, D. L., Michels, J. D., & Lawton, W. J. (1996). Body consciousness, illness-related impairment, and patient adherence in hemodialysis. *Journal of Consulting and Clinical Psychology*, *64*, 147–152.

Clark, D. M. (1986). A cognitive approach to panic. *Behaviour Research and Therapy*, *24*, 461–470.

Cohen, J. D. (1988). *Statistical power analysis for the behavioural sciences* (2nd ed.). New York: Academic Press.

Damasio, A. R. (1994). *Descartes error: Emotion, reason and the human brain*. New York: Avon.

Dawson, M. E., Schell, A. M., & Catania, J. J. (1977). Autonomic correlates of depression and clinical improvement following electroconvulsive shock therapy. *Psychophysiology*, *14*, 569–578.

Denninger, J. W., Papakostas, G. I., Mahal, Y., Merens, W., Alpert, J. E., Nierenberg, A. A., et al. (2006). Somatic symptoms in outpatients with major depressive disorder treated with fluoxetine. *Psychosomatics*, *47*, 348–352.

Dunn, B. D., Dalgleish, T., & Lawrence, A. D. (2006). The somatic marker hypothesis: A critical evaluation. *Neuroscience and Biobehavioural Reviews*, *30*, 239–271.

Dunn, B. D., Dalgleish, T., Lawrence, A. D., & Ogilvie, A. D. (in press). The accuracy of self-monitoring and its relationship to self-focused attention in dysphoria and clinical depression. Journal of Abnormal Psychology.

Ehlers, A. (1998). Why Van der Does, Van Dyck and Spinhoven (1997) did not demonstrate that superior heartbeat perception in panic disorder is partly an artefact. *Journal of Affective Disorders*, *49*, 241–244.

Ehlers, A., & Breuer, P. (1992). Increased cardiac awareness in panic disorder. *Journal of Abnormal Psychology*, *101*, 371–382.

Ehlers, A., & Breuer, P. (1996). How good are patients with panic disorder at perceiving their heartbeats? *Biological Psychology*, *42*, 165–182.

First, M. B., Spitzer, R. L., Gibbon, M., & Williams, J. B. W. (1994). *Structured clinical interview for DSM-IV axis I disorders: Clinician version*. Washington DC: American Psychiatric Association.

Flett, G. L., Vredenburg, K., & Krames, L. (1997). The continuity of depression in clinical and non-clinical samples. *Psychological Bulletin*, *121*, 395–416.

Hamilton, M. (1960). A rating scale for depression. *Journal of Neurology, Neurosurgery and Psychiatry*, *12*, 56–62.

James, W. (1884). What is emotion? *Mind*, *19*, 188–205.

Kirmayer, L. J. (2001). Cultural variations in the clinical presentation of depression and anxiety: Implications for diagnosis and treatment. *Journal of Clinical Psychiatry*, *62*(S13), 22–28.

Miller, L. C., Murphy, R., & Buss, A. H. (1981). Consciousness of body: Private and public. *Journal of Personality and Social Psychology*, *41*, 397–406.

Musselman, D. L., & Nemeroff, C. B. (2000). Depression really does hurt your heart: stress, depression, and cardiovascular disease. In E. A. Mayers, & C. B. Saper (Eds.), *Progress in brain research*, Vol. 122 (pp. 43–59). Elsevier Science.

Mussgay, L., Klinkenberg, N., & Ruddel, H. (1999). Heart beat perception in patients with depressive, somatoform, and personality disorders. *Journal of Psychophysiology*, *13*, 27–36.

Nelson, H. E. (1982). *National Adult Reading Test (NART) Test Manual*. Windsor: NFER Nelson.

Plotsky, P. M., Owens, M. J., & Nemeroff, C. B. (1998). Psychoneuroendocrinology of depression: Hypothalamic–pituitary–adrenal axis. *Psychiatric Clinics of North America*, *21*, 293–307.

Prinz, J. J. (2004). *Gut reactions*. Oxford: Oxford University Press.

Schandry, R. (1981). Heart beat perception and emotional experience. *Psychophysiology*, *18*, 483–488.

Shaw, B. F., Vallis, T. M., & McCabe, S. B. (1985). The assessment of the severity and symptom patterns in depression. In E. E. Beckham, & W. R. Leber (Eds.), *Handbook of depression: Treatment, assessment and research* (pp. 372–407). Homewood, IL: Dorsey Press.

Silvia, P. J., & Gendolla, G. H. E. (2001). On introspection and self-perception: Does self-focused attention enable accurate self-knowledge? *Review of General Psychology*, *5*, 241–269.

Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983). *Stait-Trait Anxiety Inventory (Form Y)*. Palo Alto, CA: Mind Garden.

Teasdale, J. D., & Barnard, P. J. (1993). *Affect, cognition and change*. Hove, UK: Lawrence Erlbaum Associates.

Tylee, A., & Gandhi, P. (2005). The importance of somatic symptoms in depression in primary care. *Primary Care Companion Journal of Clinical Psychiatry*, *7*, 167–176.

Van-der-Does, A. J. W., Van-Dyck, R., & Spinhoven, P. (1997). Accurate heartbeat perception in panic disorder: Fact and artefact. *Journal of Affective Disorders*, *43*, 121–130.

Van-der-Does, A. J. W., Antony, M. M., Ehlers, A., & Barsky, A. J. (2000). Heartbeat perception in panic disorder: A reanalysis. *Behaviour Research and Therapy*, *38*, 47–62.

Weisz, J., Balazs, L., & Adam, G. (1988). The influence of self-focused attention on heartbeat perception. *Psychophysiology*, *25*, 193–199.

Whitehead, W. E., Drescher, V. M., Heiman, P., & Blackwell, B. (1977). Relation of heart rate control to heart beat perception. *Biofeedback and Self-regulation*, *2*, 371–392.