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Heart-beat perception, panic/somatic symptoms and anxiety sensitivity in children

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Abstract
There is considerable evidence implicating heart-beat perception (HBP) accuracy and anxiety sensitivity (AS) in the development of panic in adults. However, to date there have been no studies exploring the association between HBP, AS and childhood panic/somatic symptoms. Seventy-nine children aged 8 to 11 years completed a mental tracking paradigm (Psychophysiology 18 (1981) 483) to assess HBP, the Children's Anxiety Sensitivity Index (J Clin Chil Psychol 20 (1991) 162) and the Screen for Childhood Anxiety Related Emotional Disorders (J Am Acad Child Adoles Psych 38 (1999) 1230). Those with good HBP(n = 7, 9%) had significantly higher panic/somatic symptoms (t = _1.71, P _ 0.05), and AS (t =_2.16, P _ 0.02) than those with poor HBP. There were no effects of age, sex or BMI on HBP. Those with high levels of panic/somatic symptoms were seven times more likely to have good HBP and had AS scores 1 S.D. higher than the remainder of the sample. Multivariate analyses revealed that these two phenotypes had independent associations with high panic/somatic symptoms. These results extend the literature on HBP and panic and suggest that in children, as in adults, increased panic/somatic symptoms are associated with enhanced ability to perceive internal physiological cues, and fear of such sensations.

Keywords: Heart beat perception (HBP); Children; Anxiety sensitivity (AS); Panic symptoms; Somatic symptoms

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1. Introduction

Two key features of panic disorder (PD) are sudden bodily sensations such as a pounding or racing heart, and the interpretation of these sensations as harmful or dangerous (Clark, 1986; Ehlers, 1991). This has led to the development of psychological models of PD which emphasise catastrophic interpretations of bodily sensations, and suggest that panic attacks are triggered by internal cues which are interpreted as threatening resulting in anxiety (e.g. Clark, 1986, 1988; Clark & Ehlers, 1993; McNally, 1999). Such theories have led to experimental research exploring individual differences in the perception of bodily cues (interoception), specifically good heartbeat perception (HBP) (Ehlers, Margraf, & Roth, 1988), and fear of anxiety sensations or anxiety sensitivity (AS: Reiss, 1986), as potential phenotype factors for development of PD.

A variety of designs has been utilised to explore heart-beat perception in relation to panic and associated presentations, but the most reliably replicable results have been obtained using the mental tracking paradigm (Schandry, 1981). In this task individuals are asked to count silently to themselves the heart beats they feel during a discrete period of time. Using this technique, PD patients have been found to be better at counting their heart beats without taking their pulse than normal controls (Harbauer-Raum, 1987 described in Ehlers & Breuer, 1996), individuals with infrequent panic attacks (Ehlers and Breuer, 1992 study 2; Van der Does, Antony, Ehlers, & Barsky, 2000), simple phobia (Ehlers and Breuer, 1992 study 2), depression (Ehlers and Breuer, 1992 study 2; Van der Does, Willem, Van Dyck & Spinhoven, 1997), or palpitations, but not PD (Van der Does et al., 2000), although some studies have not found the expected group differences (Hartl, 1992, described in Ehlers and Breuer, 1992; Antony et al., 1995; Barsky, Cleary, Sarnie, & Ruskin, 1994; Van der Does et al., 1997). Finally, longitudinal studies have demonstrated that good HBP at initial assessment is related to maintenance of PD in treated patients, recurrence of panic attacks in initially remitted patients and maintenance of panic attacks in untreated frequent panickers (Ehlers, 1995). Previous studies indicate that males and those of lower BMI have better HBP (Ehlers and Breuer, 1992), although these factors do not generally account for the group differences seen (Jones, 1994). To our knowledge no studies have yet explored the relationship between heartbeat perception and panic symptoms in a child population.

Anxiety sensitivity (AS) is the fear of anxiety sensations such as pounding heart, breathlessness and nausea, due to beliefs that these sensations have harmful or dangerous consequences (AS: Reiss, 1986). AS has been examined in numerous studies of anxiety in general, and panic disorder in particular (see Cox, Borger, & Enns, 1999 for a review of the empirical literature). AS is conceptually and empirically distinct from more general tendencies to experience anxiety in many situations reflected in scales of trait anxiety (McNally, 1999). High AS scores are associated with onset and maintenance of PD (Ehlers, 1995; Maller and Reiss, 1992; Schmidt, Lerew, & Jackson, 1997, 1999; see also review by Schmidt, 1999). Furthermore, AS level has been found to discriminate between individuals with PD and other anxiety disorders, with the exception of post-traumatic stress disorder (Taylor, Koch, & McNally, 1992). Specifically, it appears that it is fear of rapid heart rate in particular, and also dizziness, feeling short of breath and feeling shaky that best discriminate PD from the other anxiety disorders (Taylor, Koch & McNally, 1992; Hazen, Walker, & Stein, 1994; Apfeldorf, Shear, Leon, & Portera, 1994). Interestingly, AS in adults has also been shown to be associated with accurate HBP in both non-clinical (Sturges and Goetsch, 1996, though only after an arithmetical stress test), and clinical (Van der Does et al., 1997, 2000) samples. This provides further evidence supporting theories of 'fear of fear' or catastrophic interpretations of bodily sensations in the development and maintenance of PD (e.g. Clark, 1986, 1988; Clark and Ehlers, 1993).

In contrast to work on heart-beat perception, AS has been explored in child populations, where it has been shown to distinguish between children with anxiety disorders and controls (Rabian,

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Peterson, Richters, & Jensen, 1993; Vasey, Daleiden, Williams, & Brown, 1995), and between children with PD as compared to other anxiety disorders (Kearney, Albano, Eisen, Allan, & Barlow, 1997; for a review see Silverman, 1999). AS scores are also associated with total number of panic symptoms, number of panic attacks in the past year and month, amount of distress caused by the attacks and perceived seriousness of the attacks (Lau, Calamari, & Waraczynski, 1996), and predict panic symptoms after controlling for trait anxiety and depression (Calamari et al., 2001; see Silverman, 1999, for a review).

To date there have been no published studies of the associations between HBP, anxiety symptoms, specifically panic, and AS within children or adolescents. In the present sample we tested these associations in a sample of children aged 8 to 11 years. First, we investigated whether children can accurately perceive their own heart beats using a mental tracking paradigm. Second, we examined the characteristics of those with good HBP, and tested the hypothesis that these children would have higher panic/somatic and AS scores, but not other anxiety scores. Third, we examined the specificity of the association between AS and panic/somatic symptoms. Finally, we tested whether good HBP and AS were independently associated with high levels of panic/somatic symptoms.

2. Method

2.1. Participants

Children from four classes in a primary school in south east London were approached and invited to take part in a study of the development of 'feelings and emotions' in children. Of the 126 children invited to take part, 79 completed the battery of tasks and questionnaires, a response rate of 63%. The complete battery of tests took around 2 h, and the children were individually removed from the class during this time. This may account for the response rate being lower than is seen in school-based studies in which the child all complete questionnaires within a single classroom session. There were 34 boys and 45 girls in the sample, and the children were aged 8 to 11 years (mean, 9.67; S.D., 0.89). The sample was 70% white and of above average socioeconomic status.

2.2. Procedure

Heart-beat perception was assessed using the mental tracking paradigm (Schandry, 1981). Subjects were asked to count silently the heart beats that they felt during three signaled intervals (estimated numbers of heart beats), and were told not to take their pulse or to use any other strategies, such as holding their breath. This was visually checked by the testers who were trained psychology graduates. During each trial, subjects were first presented with a warning stimulus (800 Hz, 65 dB, 100 ms) to prepare them for the trial. The warning stimulus was given 500 ms after an R wave was recorded on the subjects electrocardiogram. The start signal (1000 Hz, 65 dB, 50 ms) was triggered immediately after the third R wave that followed the warning stimulus. The tone signaling the end of the counting period (1000 Hz, 65 dB, 50 ms) was given when the timed interval was up and 300 ms after the last R wave had elapsed. The computer program determined the number of R waves occurring during the counting interval, i.e. the actual number of heartbeats. Each child undertook three trials (one of each of the lengths 35, 25 and 45 s), preceded by a test trial of 10 s (data not used). To prevent distraction and remove the possibility of cheating, children were seated so that they could not see the computer screen or ECG, whilst doing the test.

The height and weight of each child was recorded in order to calculate body mass index (BMI) as the standard ratio of weight in kg divided by the square of height in meters.

2.3. Questionnaires

The children completed the Screen for Childhood Anxiety Related Emotional Disorders

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(SCARED: Birmaher et al., 1997, 1999) and the Children's Anxiety Sensitivity Index (CASI: Silverman, Fleisig, Rabian & Peterson, 1991). The SCARED has been shown to have excellent concurrent face validity (Muris et al., 1998), and psychometric properties (Birmaher et al., 1999). Furthermore, the SCARED was designed to have five subscales, which have been confirmed by factor analysis: panic/somatic symptoms, general anxiety, separation anxiety, social anxiety and school phobia (Birmaher et al., 1999). The CASI assesses children's fears of anxiety sensations, with items such as 'It scares me when I feel like I am going to faint', and has sound psychometric properties (Silverman, Fleisig, Rabian & Peterson, 1991). Both questionnaires use three-point Likert scales and were administered on a laptop computer by a member of the research team. Items were read aloud to any children that had difficulty reading the questions.

2.4. Data analysis

Percentage error scores in heart-beat perception were defined as the absolute difference between the actual number of heart beats (AB) and counted heart beats (CB), as a percentage of the number of actual heartbeats (i.e. ((AB_CB)/AB) × 100). These scores were then used to classify children as having good or poor HBP. Bivariate associations were examined using chi-square (for dichotomous variables) and *t*-tests (for continuous variables), and the multivariate analysis was conducted using a logistic regression.

3. Results

3.1. Distribution of error scores and definition of accurate perception

Mean error scores were obtained by averaging the percentage error scores for each of the trials. Fig. 1 shows the distribution of these mean scores. As can be seen from this figure the children were generally rather poor at the task, with a mean error rate of 70% across the three trials.

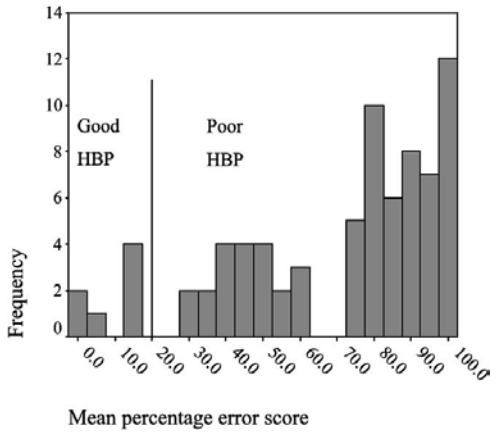

Fig. 1. Distribution of mean percentage error scores.

Nine of the children (12%) were unable to feel any of their heart beats. However, a small group ofchildren were able to detect and count their heart beats with a reasonable level of accuracy (up to 20% error), and were classified as having good HBP (seven children, or 9% of the sample), which is in line with previous studies with adults (see Van der Does et al., 2000 for a review). For the children with good HBP the range of error scores was 0.83 to 16.41, with a mean of 10.06, as compared to those with poor HBP whose error-rates ranged from 30.16 to 100 with a mean of 75.94.

3.2. Characteristics of children with good HBP

The next stage of the analysis was to examine the characteristics of those with good vs. poor HBP. There were no significant differences between these groups for age, sex or BMI (see Table 1), but

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there was a non-significant trend indicating that those with good HBP had slightly higher mean heart rates over the three trials than those with poor HBP.

The second hypothesis we examined in this study was that children with good HBP would score significantly higher on panic/somatic symptoms and on AS compared to the children with poor HBP, but not on the other anxiety scales. Planned comparisons were used to test this hypothesis, comparing mean scores on the five anxiety scales from the SCARED and CASI for the good and poor HBP groups. Given the unidirectional hypotheses, we used one-tailed significance tests for these comparisons. As expected, those with good HBP had significantly higher levels of both panic/somatic symptoms and AS than those with poor HBP. For example, those with good HBP had panic/somatic scores of 9.57 compared to 6.42 in the remainder of the sample. A previous study with children ascertained from a mood/anxiety disorders clinic (Birmaher et al., 1997) found a mean level of panic/somatic symptoms in the anxiety cases group of 9.4. This suggests that the children with good HBP are experiencing clinically significant levels of panic symptoms.

Table 1
Characteristics of children who were poor vs. good on the HBP task

Scale	Good HBP *M* (or % of group)	Poor HBP *M* (or % of group	*t* test, one-tailed or Chi-square
Age	9.68	9.76	0.26
Male (percentage)	42.9	41.2	0.01
BMI	18.59	17.76	-0.67
Heart beats per min	90	82	-1.77+
Panic/somatic	9.57	6.42	-1.71.
General anxiety	6.86	6.15	0.47
Separation anxiety	8.71	6.46	-1.50+
Social phobia	5.43	5.82	0.30
School phobia	3.14	2.34	-1.21
Anxiety sensitivity	34.1	29.3	-2.16..

+*P*_0.10; .*P*_0.05; ..*P*_0.02.

Those with good HBP also had higher separation anxiety symptoms, although this was a non-significant trend. There were no significant differences between the two groups for any of the other anxiety symptom scales.

3.3. Specificity of association between anxiety sensitivity and panic symptoms
As an initial stage of this analysis, we examined the correlations between AS and all the anxiety scale scores. These were 0.62, 0.56, 0.62, 0.47 and 0.40 for panic/somatic, general anxiety, separation anxiety, social anxiety and school anxiety symptoms respectively. As such, the numerically highest correlations were between AS and the somatic/panic and separation anxiety scales. In order to test further the specificity of the association between AS and panic/somatic symptoms over and above their joint association with general anxiety symptoms, we calculated the partial correlation between panic/somatic symptoms and AS controlling for general anxiety,

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and this was 0.38 (*P* _ 0.0001).

3.4. Prediction of panic/somatic symptoms from good heart-beat perception and anxiety sensitivity

The final stage of the analyses was to examine whether good HBP and AS independently predicted high levels of panic/somatic symptoms. First, we identified our high panic/somatic group. The only published cut-offs for this measure apply to clinical samples with a wide age range (Birmaher et al., 1997), and using the cut-off of 9 given for the panic/somatic scale we had a prevalence of high panic/somatic symptoms of 38% in our sample. As this seemed too high we increased the cut-off to 11, which identified 24% of the sample as having high panic/somatic symptoms. The prevalence of good HBP in this group was 26.3%, more than seven times as high as in the remainder of the sample (3.4%, c2 = 9.25, *P* _ 0.0001). Similarly, this group had AS scores more than 1 S.D. higher than the remainder of the sample (mean, 34.11; S.D., 3.75; and mean, 28.51; S.D., 5.57, respectively, *t* = 4.09; df = 76; *P* _ 0.0001). It is clear that both good HBP perception and AS are associated with high levels of panic/somatic symptoms, and the final question to be considered was whether these two phenotypes were independently associated with panic/somatic symptoms. A multivariate logistic regression predicting high panic/somatic scores from both good HBP and AS scores revealed significant effects of both good HBP (B = 2.08; S.E. = 1.01; Wald = 4.22, *P* _ 0.05), and AS scores (B = 0.20; S.E. = 0.07; Wald = 9.18; *P* _ 0.002; *R*2 = 0.33).

4. Discussion

Two cognitive phenotype factors have been demonstrated to be associated with onset of PD in adults: good heart-beat perception (HBP) and anxiety sensitivity (AS), and whilst the latter has been shown to be associated with panic symptoms in children (Silverman, 1999; Lau, Calamari & Waraczynski, 1996), the former has yet to be explored in a child sample. In this study we assessed both these cognitive predictors of panic in a sample of school children. First, we found that children could understand and complete the mental tracking paradigm, and we were able to classify the children into two groups (good vs. poor HBP) on the basis of their mean error scores, with 9% of the children classified as having good HBP (fewer than 20% errors).

Second, we found that children with good HBP had significantly higher panic/somatic symptoms and AS scores than those with poor HBP, and they also tended to show higher levels of separation anxiety symptoms. There were no significant differences between those with good and poor HBP for general anxiety, social phobia or school phobia symptoms, indicating a specific association between anxiety related to physiological cues and HBP as compared to anxiety of a general or social focus. This indicates that HBP is not only conceptually, but empirically distinct from trait anxiety which is associated with all types of anxiety symptoms. Furthermore, there were no significant differences between those with good vs. poor HBP for any of the descriptive variables including age, sex, and BMI, suggesting that these variables did not account for our findings.

Third, as has been demonstrated previously in both adult (Schmidt, 1999) and child (Silverman, 1999) samples, there was mild evidence of specificity between AS and panic/somatic anxiety symptoms as compared to general or social anxiety symptoms. AS correlated slightly more strongly with panic/somatic and separation anxiety symptoms than the other scales, and AS and panic/somatic symptoms were still significantly correlated once the effects of general worry were partialled out. Interestingly, as with good HBP, the other anxiety scale substantially associated with AS was separation anxiety. These data provide modest support for the conceptualisation of AS as a unique predictor of panic symptoms distinct from trait anxiety (McNally, 1999), which is associated with all aspects of anxiety symptomatology.

Finally, both good HBP and AS scores were strongly and significantly associated with high levels of panic/somatic symptoms, and multivariate analyses revealed these two cognitive variables to

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be independently associated with panic/somatic symptoms. As such, although these phenotypes are conceptually and empirically associated with one another they have unique and independent associations with panic/somatic symptoms.

One somewhat unexpected finding in these data was the trend indicating an association between HBP and separation anxiety. As separation anxiety is specific to childhood its association with HBP has not previously been explored. However, on two levels there appear to be links betweenseparation anxiety and panic. First, somatic symptoms such as nausea, headache and vomiting are common in younger children with separation anxiety disorder (SAD), and in older children symptoms such as palpitations, dizziness and feeling faint occur (American Psychiatric Association, 1994). Second, separation anxiety has been shown to be a risk factor for PD (Silove & Manicavasagar, 2001) and particularly for agoraphobia (Gittelman & Klein, 1984) indicating that there may be a developmental sequence with separation anxiety leading to later PD and agoraphobia. Third, good HBP shows the strongest association with PD with agoraphobia (Ehlers & Breuer, 1996). As such, separation anxiety symptoms may precede panic and agoraphobic symptoms, and the association with HBP and also AS may form part of this developmental trajectory.

This study has several limitations. The first is the small sample size, which combined with the rarity of good heart-beat perception meant that we identified just seven children with good HBP. However, this is similar to rates in adults which have tended to range from 7–10% in normal control samples, and 0–25% in differing psychiatric groups (see Van der Does et al., 2000 for a review). Second, we used children selected from a school-obtained sample rather than a clinically ascertained sample. These two aspects of the study clearly limit the impact of our results and suggest that replication would be particularly useful in a larger sample using subjects diagnosed with panic disorder. However, it should be noted that even with this small population-based sample we had sufficient power to identify the predicted effects. Third, the sample was of above average SES, and as such these results need to be replicated with a broader range of families. Fourth, we relied solely on self-report for our measures of AS and anxiety symptoms, and future studies would benefit from additional parent- or teacher-reported data. Finally, the data in this study were cross-sectional and as such we cannot make strong statements regarding the direction of effects.

In summary, despite the limitations of the current study, these data demonstrate an association between good heart-beat perception and both panic/somatic symptoms and anxiety sensitivity. There was also a non-significant association between good heart-beat perception and separation anxiety, which may reflect a developmental over-lap between separation anxiety and panic/somatic symptoms. In contrast, good heart-beat perception was not related to general or social types of anxiety, suggesting that this ability is unrelated to trait anxiety. This is in line with previous research in adults that usually did not find correlations between measures of trait anxiety and heart beat perception (e.g. Ehlers & Breuer, 1992). Second, given the role of anxiety sensitivity in the development of PD in both children and adults, we tested whether AS and good HBP were independently associated with high levels of panic/somatic symptoms and found that they were. These results indicate that cognitive biases reflecting interoception and fear of anxiety sensations are associated with panic/somatic symptoms in children as in adults, and may thus reflect risk for subsequent development of panic disorder, and be good targets for intervention or treatment.

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