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Research report

Testing the tripartite model in young adolescents: Is hyperarousal specific for anxiety and not depression?

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Abstract

Background: To clarify the distinction between anxiety and depression, the tripartite model was introduced. According to this model, physiological hyperarousal (PH, i.e. autonomic hyperactivity) is specific for anxiety and not depression. Research on the relation between anxiety, depression and physiological measures representing arousal is lacking.

Methods: Parent- and self-reported anxiety and depressive problems were assessed using the CBCL and RCADS. Heart rate (HR), heart rate variability in the low frequency (HRV LF) and respiratory sinus arrhythmia (RSA) were used as indices for autonomic arousal.

Results: Parent-reported anxiety was associated with low RSA in supine posture. This association was also found for self-reported anxiety problems, but only in boys. These findings point towards high arousal in anxiety. Self-reported depressive problems were associated with low HRV LF in standing posture and high RSA in supine posture in boys, pointing towards low arousal in depression. However, self-reported depressive problems were also associated with high HR in standing posture and with low HRV LF in supine posture in girls, suggesting high arousal in depression.

Limitations: Although HRV LF in standing posture is primarily sympathetically mediated, and HRV LF in supine posture is primarily vagally mediated, the association between HRV LF and sympathetic versus vagal function is not exclusive. Thus, HRV LF measures are merely approaches of high or low arousal.

Conclusions: Some evidence was found for hyperarousal in anxiety, but also for hyperarousal in depression. Apparently, the idea of hyperarousal in anxiety and not in depression is too simple to reflect the more complex reality.

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Keywords: Anxiety; Depression; Physiological hyperarousal; Autonomic functioning; Young adolescents

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1. Introduction

Anxiety and depressive problems in childhood and adolescence occur frequently (Treffers, 2000; Verhulst et al., 1997), result in considerable suffering and

impairment, and tend to persist (Ferdinand et al., 1999; Ferdinand and Verhulst, 1995; Pollack et al., 1996; Treffers and Öst, 2001). Therefore, it is important to investigate their etiology, and to develop an adequate taxonomy, that can serve as a cornerstone for high quality assessment.

Since anxiety and depression often co-occur, it is doubted if the two represent distinct constructs (Angold et al., 1999; Axelson and Birmaher, 2001; Essau et al., 2000; Goodwin, 2002; Kessler et al., 1999; Stein et al., 2001). In an attempt to improve the taxonomy of anxiety and depression, Clark and Watson introduced the tripartite model (Clark and Watson, 1991). According to this model, anxiety and depression share negative affect (NA) as a common factor, whereas depression is specifically characterized by low levels of positive affect (PA), and anxiety by physiological hyperarousal (PH; i.e. autonomic hyperactivity, motor tension). Since the introduction of this model, it has been frequently used and tested, both in children as well as in adults, and it has become well known in the field of anxiety and depression research.

Empirical evidence for the usefulness and fit of the tripartite model was provided by studies that employed factor analyses (Chorpita, 2002; Laurent and Ettelson, 2001). While several studies investigated the association between anxiety or depression and NA or PA (Chorpita, 2002; Joiner et al., 1996; Laurent et al., 1999), fewer have investigated whether an association with PH was specific for anxiety and not for depression (Joiner et al., 1999; Laurent et al., 2004). In the studies that have investigated the association between PH and anxiety or depression, questionnaires were used to measure PH. However, the items that were used to measure PH tended to overlap with items tapping vegetative symptoms of anxiety, which might explain the associations that were found between PH and anxiety. In our opinion, physiological measures representing arousal would be more appropriate to measure PH (see also Laurent and Ettelson, 2001). To our knowledge, investigations aimed at testing the validity of the PH component of the tripartite model against physiological measures representing arousal, are lacking.

Physiological measures that give an impression of the activity of the autonomic nervous system (ANS) are highly related to arousal. In a state of high arousal, heart rate (HR) is high. HR is influenced by two competing autonomic branches. The sympathetic branch has the function of increasing HR. Hence high arousal is associated with high sympathetic activity. The parasympathetic/vagal branch takes care of decreasing HR. High arousal is therefore associated with low vagal activity. Thus, to assess levels of arousal, it is important to

measure HR. In addition, it is important to obtain other estimates of ANS functioning to give an impression of the activity of the separate branches of the ANS.

Some studies have investigated the relation between anxiety and autonomic functioning in children or adolescents (Gerra et al., 2000; Kagan et al., 1988; Mezzacappa et al., 1997). All of these studies found associations between higher HR and higher levels of anxiety. However, these studies were confined to small, nonrepresentative samples. None of these studies focused on both anxiety and depression, so firm conclusions about the specific association between anxiety and autonomic measures representing arousal, in comparison to depression, could not be drawn.

In a previous study, we investigated the association between internalizing and externalizing problems and autonomic functioning in the TRacking Adolescents' Individual Lives Survey (TRAILS) general population sample (Dietrich et al., 2007). For instance, evidence was found for higher HR in individuals with internalizing problems (affective, anxiety and somatic problems taken together). In the present study, anxiety and depressive problems were investigated separately. The TRAILS study provided the opportunity to investigate associations with HR, but also with heart rate variability (HRV). HRV reflects changes in beat-to-beat variations in HR. HRV can be analyzed by means of spectral analysis, which portrays the variance in HR as a function of frequency. The frequency range can be divided into low frequency HRV (generally between 0.04 and 0.14 Hz), and high frequency HRV (above 0.14 Hz). Low frequency HRV (HRV LF) measured in standing position, is primarily sympathetically mediated and vagal effects are inhibited, whereas in the supine posture vagally mediated effects predominate. HRV in the high frequency band is often called respiratory sinus arrhythmia (RSA), and is primarily vagally mediated (Mezzacappa et al., 1997). Therefore, based on the tripartite model, we expected anxiety problems to be associated with high HRV LF in standing posture and high HR in both postures. Further, we expected anxiety problems to be related to low HRV LF in supine posture and low RSA in both postures. No signs of hyperarousal were expected to be found in depression. Since the tripartite model does not further describe arousal in depression, it was unclear if we would expect no associations between depression and arousal at all, or even low arousal levels in depression.

In addition to our previous work that only concerned parent-reports, self-reported anxiety and depressive problems were investigated. Examining self-reported problems may be an important extension, since anxiety

and depression are highly subjective, and some of the more unobservable symptoms are often under-reported by parents (Comer and Kendall, 2004).

In summary, the aim of the present study was to investigate the putative associations of both parent- and self-reported anxiety problems and depressive problems with physiological measures representing arousal (HR, HRV LF, and RSA) in a large population sample of young adolescents. Based on the tripartite model (Clark and Watson, 1991), we expected specific associations between these physiological measures representing arousal and anxiety, indicating hyperarousal in anxiety, but not in depression.

2. Methods

2.1. Sample and procedure

Participants were 10- to 13-year-old young adolescents who participated in the TRacking Adolescents' Individual Lives Survey (TRAILS), a large Dutch general population study ($n=2230$). In the TRAILS study, not only young adolescents, but also their parents and their teachers participated. The young adolescents filled out questionnaires at school, in the classroom, under the supervision of one or more TRAILS assistants. In addition to that, a number of physiological and neurocognitive parameters, such as heart rate, were assessed in a separate room at school on another school day. Further, well-trained interviewers visited one of the parents or guardians (preferably the mother, 95.6%) at their homes to administer an interview covering a wide range of topics, for instance developmental history and somatic health. Besides the interview, the parent was asked to fill out some questionnaires concerning their child's mental health and behaviour. Teachers gave the opportunity to let the young adolescents participate during school hours and filled out a brief questionnaire for all TRAILS-children in their class.

For the present manuscript, we included 1027 boys and girls (47% versus 53%, mean age 11.0 years, $SD=0.5$) for whom reliable physiological measures could be computed. To examine possible selective attrition, a stepwise regression analysis was performed. The 1027 participants did not differ from the other 1203 participants in the TRAILS study regarding gender, pubertal stage, Body Mass Index, and anxiety or depression scores. Age predicted attrition; older participants were less likely to take part in the physiological measurements. Nevertheless, the age difference (11.02 versus 11.15 years) and effect size (1.2%) were small. Written consent was obtained from the participant's

parents. The study was approved by the Central Dutch Medical Ethics Committee. Detailed information about the TRAILS sample selection and characteristics has been reported elsewhere (de Winter et al., 2005).

2.2. Measures

2.2.1. Anxiety and depressive problems

2.2.1.1. Parent-reports: CBCL. The Child Behavior Checklist (CBCL) is a parent-report questionnaire for assessing problems in 6- to 18-year-olds and contains 120 items on behavioural or emotional problems in the past six months, that are scored on a 3-point scale (0 = not true, 1 = somewhat or sometimes true, 2 = very or often true). The good reliability and validity of the American version of the CBCL were confirmed for the Dutch translation (De Groot et al., 1994). The original empirical syndrome scales for the CBCL that were used in our previous study, were based on multivariate statistical analysis on data from large samples. To fit more closely with the clinical-diagnostic approach represented by the DSM (APA, 2006), six new DSM-IV scales were recently constructed: Affective Problems, Anxiety Problems, Somatic Problems, Attention Deficit/Hyperactivity Problems (ADH), Oppositional Defiant Problems (OD), and Conduct Problems (CD) (Achenbach and Dumenci, 2001; Achenbach et al., 2003).

In the present study, we used the Anxiety Problems and Affective Problems scales to assess anxiety and depressive problems. The Anxiety Problems scale consists of 6 items that reflect symptoms of DSM-IV generalized anxiety disorder, separation anxiety disorder, and specific phobia. The Affective Problems scale consists of 13 items, and reflects symptoms of DSM-IV dysthymia and major depressive disorder. The Cronbach's alphas based on the present data set were .67 for the Anxiety Problems scale, and .66 for the Affective Problems scale. The ADH, OD and CD scales were summed and used as a measure of Disruptive Behaviour, to adjust for comorbidity.

2.2.1.2. Self-reports: RCADS. We assessed self-reported anxiety and depressive problems using the Revised Child Anxiety and Depression Scale (RCADS; Chorpita et al., 2000, 2005). The RCADS assesses anxiety and depressive symptoms thoroughly; it contains 47 items that are scored on a 4-point scale (0 = never, 1 = sometimes, 2 = often, 3 = always). The questionnaire covers six of the DSM-IV dimensions of anxiety disorders and depressive disorder: separation anxiety disorder, generalized anxiety disorder, social

phobia, panic disorder, obsessive compulsive disorder, and major depressive disorder (MDD). In this study, a Total Anxiety scale was computed by summing the scores on the separate anxiety items and dividing this by the number of items that were completed. Similarly, a MDD scale was computed, and used as a measure of depressive problems. The Cronbach's alphas based on the present data set were .91 for the Total Anxiety scale, and .73 for the MDD scale.

2.2.2. Physiological measures

Heart rate (HR) measurements were performed in a quiet room at school, one child at a time. First, participants were asked to lie down. While supine, the procedure was explained to them. A three-lead electrocardiogram was applied to register HR. Participants were encouraged to relax and asked not to move or speak during data acquisition.

Participants were in supine position for approximately 5 min before measurement began. Recordings did not start until signals had reached a stabilized steady-state. Then HR signals were registered for 4 min in supine position during spontaneous breathing, followed by 2 min in standing position, again after signals had stabilized. Recordings were digitized (sample rate 100 Hz, using a DAS-12 data acquisition card for notebooks, Keithley Instruments, Cleveland, Ohio, USA) and stored on hard disk for off-line analyses.

HR was calculated as 60,000 divided by the mean inter beat interval (IBI), expressed in beats per minute (bpm). Calculation of HRV LF and RSA was performed by spectral analysis in the CARSPAN software program using estimation techniques based on Fourier transformations (Robbe et al., 1987). The power spectrum for the frequency range was divided into low frequency (HRV LF; between 0.07 and 0.14 Hz), and high frequency (RSA; above 0.14 Hz). The analyzed time series were checked and corrected for artefacts. More detailed information about these analysis and internal reliability of the data has been reported previously (Dietrich et al., 2006).

2.3. Statistical analyses

Descriptives were calculated for all anxiety, depression, and physiological measures. To approximate a normal distribution, HRV LF and RSA values were transformed to their natural logarithm. Linear regression analyses were performed with each physiological measure (HR, HRV LF, and RSA, both in supine and standing posture) as the dependent variable, and both CBCL Anxiety Problems and Affective Problems scales

as predictors. In addition, gender and scores on Disruptive Behaviour (i.e. summed scores of the CBCL ADH, OD, and CD DSM-IV scales) were entered as covariates, to adjust for possible confounding effects of gender and comorbid externalizing problems. Finally, Gender*Anxiety Problems and Gender*Affective Problems interactions were added to the model. These interactions were only included in the final model if they yielded significant effects. Moreover, in case of a significant effect of one of these interaction terms, additional post hoc analyses were performed for boys and girls separately.

A similar set of analyses was conducted for the Total Anxiety and MDD scales of the RCADS. The RCADS does not assess disruptive behaviour problems. Therefore, the Disruptive Behaviour scores of the Youth Self-Report (YSR) were used as a covariate in these analyses. The YSR is a self-report questionnaire that was modeled on the CBCL and contains similar items.

Preliminary analyses indicated that there were no significant effects of Body Mass Index or pubertal stage on the physiological measures or the anxiety and depressive problems scores. Hence, these factors were not considered in the analyses. A *p*-value smaller than .05 was considered statistically significant. Since we performed several statistical tests, the results may suffer from capitalization on chance: one would expect some 5% of the associations examined to be significant merely on the basis of chance. Hence, a statistically significant result in this context does not have the same weight as significant results in a classical experimental design.

3. Results

3.1. Descriptives

Mean scores and standard deviations of all the anxiety, depression, and physiological measures are shown in Table 1:

3.2. Parent-reports: CBCL

Table 2 shows the results of the linear regression analyses performed with the Anxiety Problems and Affective Problems scales of the CBCL as predictors, and physiological measures (HR, HRV LF, and RSA, in supine and standing posture) as dependent variables. Betas, *p*-values and effect sizes are presented. Betas show the direction of the association, while effect sizes give an idea of the magnitude of an association. According to Cohen (Cohen, 1988), effect sizes

Table 1
Descriptives of anxiety, depression, and physiological measures

Measures	Boys			Girls		
	<i>n</i>	Mean (SD)	Range	<i>n</i>	Mean (SD)	Range
CBCL Anxiety Problems	448	.31 (.30)	(.00–1.83)	501	.31 (.30)	(.00–1.50)
CBCL Affective Problems	448	.19 (.19)	(.00–1.00)	501	.18 (.19)	(.00–1.23)
RCADS Total Anxiety	478	.54 (.32)	(.00–1.89)	542	.61 (.33)	(.05–1.97)
RCADS MDD	478	.62 (.34)	(.00–2.10)	542	.62 (.32)	(.00–2.00)
HR supine (bpm)	484	75.8 (10.4)	(51.7–111.7)	543	79.2 (11.1)	(49.1–115.9)
HRV LF supine (ln(ms ²))	484	6.54 (1.03)	(3.79–9.66)	543	6.30 (1.07)	(3.02–9.06)
RSA supine (ln(ms ²))	484	7.47 (1.32)	(3.11–10.47)	543	7.21 (1.29)	(3.01–10.55)
HR standing (bpm)	484	92.7 (13.4)	(59.4–131.2)	543	95.5 (13.2)	(57.8–143.0)
HRV LF standing (ln(ms ²))	484	6.25 (.97)	(2.87–8.85)	543	6.13 (.91)	(3.07–8.51)
RSA standing (ln(ms ²))	484	6.00 (1.33)	(1.70–9.71)	543	5.92 (1.22)	(1.33–9.39)

Note: MDD = Major Depressive Disorder, HR = Heart Rate, HRV LF = Heart Rate Variability in the Low Frequency band, RSA = Respiratory Sinus Arrhythmia.

≥ 13.8% are large, between 5.9% and 13.8% medium, and between 1.0% and 5.9% small.

3.2.1. Anxiety

Anxiety Problems were significantly associated with low RSA in supine posture, indicating relatively low vagal activity in anxious individuals.

3.2.2. Depression

No significant associations were found between any of the physiological measures and Affective Problems. This means that the association we found between Anxiety Problems and RSA in supine posture was specific for anxiety, and not depression.

3.3. Self-reports: RCADS

The results of the linear regression analyses conducted with the RCADS scales Total Anxiety and MDD as candidate predictors, and the physiological measures (HR, HRV LF and RSA, in supine and standing posture) as dependent variables are also presented in Table 2.

3.3.1. Anxiety

A significant association was revealed between HRV LF in supine posture and the Gender*Total Anxiety interaction. When we performed the analyses for boys and girls separately, we found that the association between HRV LF in supine posture and Total Anxiety

Table 2
Associations of anxiety and depression with the physiological measures (HR, HRV LF, and RSA) in supine and standing posture

Dependent variable	Significant predictors	Beta's, <i>p</i> -values, and effect sizes (<i>R</i> ²)	
HRV LF supine	<i>RCADS</i>		
	Gender*Total Anxiety	$\beta = -.18, p = .046, R^2 = 2.2\%$	(girls; $\beta = .05, p = 0.360, R^2 = 1.0\%$ boys; $\beta = -.11, p = .079, R^2 = 0.9\%$)
	Gender*MDD	$\beta = .28, p = .005, R^2 = 2.2\%$	(girls; $\beta = -.14, p = 0.023, R^2 = 1.0\%$ boys $\beta = .11, p = 0.081, R^2 = 0.9\%$)
RSA supine	<i>CBCL</i>		
	Anxiety Problems	$\beta = -.09, p = .020, R^2 = 2.3\%$	
	<i>RCADS</i>		
	Gender*Total Anxiety	$\beta = .24, p = .015, R^2 = 1.9\%$	(girls; $\beta = .05, p = .357, R^2 = 0.2\%$ boys; $\beta = -.15, p = .018, R^2 = 1.7\%$)
	Gender*MDD	$\beta = -.21, p = .018, R^2 = 1.9\%$	(girls; $\beta = -.05, p = .389, R^2 = 0.2\%$ boys; $\beta = .15, p = .022, R^2 = 1.7\%$)
HR standing	<i>RCADS</i>		
	MDD	$\beta = .09, p = .038, R^2 = 1.6\%$	
HRV LF standing	<i>RCADS</i>		
	MDD	$\beta = -.11, p = .013, R^2 = 1.0\%$	

Note: HR = Heart Rate, HRV LF = Heart Rate Variability in the low frequency band, RSA = Respiratory Sinus Arrhythmia, MDD = Major Depressive Disorder.

was not significant in either boys or girls, but it was negative in boys, and positive in girls. Furthermore, a significant association was revealed between RSA in supine posture and the Gender*Total Anxiety interaction. Analyses regarding the association between Total Anxiety and RSA in supine posture for each sex separately revealed that in boys anxiety was significantly associated with low RSA in supine posture, indicating relatively low vagal activity in anxious boys.

3.3.2. Depression

A significant association was revealed between HRV LF in supine posture and the Gender*MDD interaction. Analyses stratified for gender revealed that in girls, MDD was significantly associated with low HRV LF in supine posture. This finding suggests higher arousal in depressed girls. Also, a significant association was found between RSA in supine posture and the Gender*MDD interaction. Post-hoc analyses revealed high RSA in supine posture in depressed boys, indicating low arousal in depressed boys. MDD was associated with high HR in standing posture, pointing towards relatively high arousal in depression. In contrast, MDD was associated with low HRV LF in standing posture, which indicates low arousal in depression.

4. Discussion

In the present study, the tripartite model (Clark and Watson, 1991) was tested by investigating putative associations of both parent- and self-reported anxiety problems and depressive problems with physiological measures of arousal (HR, HRV LF, and RSA) in a large population sample of young adolescents. Based on the tripartite model, we expected to find specific associations between these physiological measures and anxiety problems, indicating hyperarousal in anxiety, but not in depression.

4.1. Evidence supporting the tripartite model

4.1.1. Anxiety

Although effect sizes were relatively small, our findings yielded some evidence for hyperarousal in anxiety. The analyses regarding parent-reported anxiety problems revealed that anxiety problems were associated to low RSA in supine posture, indicating relatively low vagal activity in anxious individuals. This association was found for self-reported anxiety problems as well, but only in boys. These findings point towards diminished vagal activity in individuals with anxiety problems. Decreased vagal activity in anxiety may

reflect less influence of the ‘vagal brake’. According to Porges (2001), in healthy individuals removal of the vagal brake provides the opportunity to easily adapt to environmental challenges (stress), without the severe biological cost of the metabolic excitation associated with sympathetic-adrenal activation. Where this adaptive mechanism is functional in stressful circumstances for healthy individuals, in anxious individuals this vagal brake may have been constantly less active from birth, or may have become less active across development.

4.1.2. Depression

No associations were found between parent-reported depressive problems and any of the physiological measures, indicating that the association that was found between RSA and anxiety problems was specific for anxiety, and not depression. Therefore, these findings in parent-reported data supported the concept of hyperarousal specifically in anxiety, and not depression, which is in accordance with the tripartite model (Clark and Watson, 1991; Joiner et al., 1999; Laurent and Ettelson, 2001).

The tripartite model only implicates that there is no hyperarousal in depression, but it does not provide suggestions about the expected arousal patterns in depression. Interestingly, in our analyses of self-reported depression, we found some evidence pointing towards low arousal in depression. A negative association was found between HRV LF in standing posture and MDD. Further, a positive association was found between RSA in supine posture and MDD in boys. These findings suggest that depression is associated with low arousal and raise the interesting idea of low arousal in depression versus hyperarousal in anxiety.

4.2. Evidence against the tripartite model

Some of the findings were inconsistent with the tripartite model. HR is a clear measure of arousal; the higher the HR, the higher the arousal level. Therefore, we expected to find specific positive associations between HR and anxiety problems. However, no such associations were revealed. Moreover, in contrast with the findings mentioned above, self-reported depression was associated with high HR in standing posture, suggesting high arousal in depression. In addition, in girls self-reported depression was associated with low HRV LF in supine posture, which also points towards higher arousal in depression. According to the tripartite model, hyperarousal is specific for anxiety and not depression. Therefore these findings do not support the tripartite model.

4.3. Sex differences

Our findings differed between boys and girls. For instance, findings with RSA in supine posture, i.e. vagal activity, were significant in boys, and not in girls. Also in an other study, associations of vagal function with, in this case coping style, were specific for young males, and not for females (Ramaekers et al., 1998). Interestingly, our findings in boys supported the idea of low arousal in depression versus hyperarousal in anxiety. It could be that, in boys, anxiety and depression are to a large extent associated with biological factors such as vagal activity, while in girls, the associations with vagal activity are not as strong, because their problems are to a larger extent associated with other, more social, environmental factors. For example, Rice and colleagues (Rice et al., 2002) found evidence for a stronger genetic component in self-reported depressive problems in boys than in girls. The study of Boomsma and colleagues (Boomsma et al., 2005) revealed a larger influence of environmental factors on the outcome of anxiety and depression in girls than in boys, but did not find significant sex differences for genetic influences on anxious or depressed outcome.

4.4. Differences across informants and measures

Findings were different between informants. In the parent-reports (CBCL) we found some evidence in favor of the tripartite model. However, findings were less robust in self-reports (RCADS). These varying findings stress the importance of using multiple informants, also while investigating biological substrates of anxiety and depression.

Further, different physiological measures led to different findings. As stated earlier, we expected to find specific associations between HR and anxiety, since HR is the most evident measure of arousal. However, no such associations were revealed. In our previous study (Dietrich et al., submitted for publication), internalizing problems were associated with higher HR in supine posture. Nevertheless, when we performed the analyses for anxiety and depression separately for the present study, no significant associations were found. Apparently, HR in supine posture was only associated with broad-band internalizing problems, but not specifically with anxiety. Most of the support we found for the tripartite model regarded low RSA in supine posture in relation to anxiety, i.e. decreased vagal activity in anxiety. Although RSA is not as closely related to arousal as HR, these negative associations could be expected according to the tripartite model, and accord-

ing to the polyvagal theory (Porges, 2001). Decreased vagal activity points towards a less active vagal brake, which can lead to increased arousal in anxiety.

4.5. Dimensions of psychopathology and comorbidity

As mentioned above, findings can differ depending to which dimensions of psychopathology are used. Associations with HR were significant when we used to broad dimension of internalizing problems (Dietrich et al., submitted for publication), while they were not when we split this dimension up into anxiety and depression. In literature there has been some debate on how the broad dimension of internalizing problems should be subdivided (e.g. Lahey et al., 2004). Lahey and colleagues have suggested that some anxiety problems, such as separation anxiety, fears, obsessions and compulsions, are reasonably distinct from depression, but that other types of anxiety, like generalized anxiety and social phobia, are highly correlated with depression. Therefore, one could hypothesize that the anxiety problems that are more distinct from depression would differ more from depression regarding physiological arousal than the depression-related anxiety problems. Yet, additional analyses based on this alternative method of defining subdimensions did not reveal different results (findings can be obtained from corresponding author).

Of course, there is a lot of comorbidity of anxiety and depressive problems; ‘pure’ cases of individuals with only problems in one of these dimensions are rare, especially in a general population sample. Comorbidity can influence the results of a study. Also comorbidity with externalizing problems can play a role, since arousal is not only associated with anxiety, but also with these problems (Thayer and Lane, 2000). In the present study, we took into account the influence of comorbidity, by correcting for coexisting problems in our analyses. However, this only eliminates the variance associated with comorbid problems, but does not eliminate the comorbidity itself. To tackle the problem of comorbidity, future clinical studies could try to select participants with ‘pure’ psychopathology – scoring high on one dimension and low on the others –, although this will probably not be easy, since comorbidity is usually rather the rule than the exception.

4.6. Sample characteristics

The present study made use of data from the general population. The model of Clark and Watson (1991) was based on findings in clinical samples. Because of differences in symptom levels, different associations

between internalizing problems and physiological measures might be found in clinical versus general population samples. Thus, to gain more insight in the veracity of the model, future replication studies in clinical samples are needed.

4.7. Limitations

The validity of the CBCL DSM-IV scale Anxiety Problems can be questioned (Ferdinand, *in press*). However, in spite of this, the association with RSA in supine posture was specific for the Anxiety Problems scale and not the Affective Problems scale. Furthermore, although HRV LF in standing posture is primarily controlled by sympathetic influences, and HRV LF in supine posture is primarily vagally mediated, the association of HRV LF in standing and supine posture with respectively sympathetic and vagal activity is not exclusive. In other words, it should be taken into account that HRV LF measures are not more or less than approaches of sympathetic and vagal activity. The same is true for RSA. Although RSA is better known and investigated as a measure of vagal activity than HRV LF in supine position, one could argue that it is important to use respiratory control procedures (Ritz and Dahme, 2006), to get an even better indication of vagal activity. In addition, pre-ejection-period (PEP) should be considered as a suitable measure for sympathetic activity (Berntson et al., 1994). Nevertheless, since associations were found between the HRV LF measures and anxiety problems in both the present study and the study of Mezzacappa and colleagues (1997), we can assume that these measures are also interesting correlates of anxiety problems.

4.8. Conclusions and implications

In the present study, we found some evidence for hyperarousal in anxiety, which supported the tripartite model of Clark and Watson (1991). Yet, some other findings pointed towards higher arousal in depression, which is in contrast with this model. Although effect sizes were small, our results illustrate that hyperarousal cannot differentiate between anxiety and depression. The idea that hyperarousal is specific for anxiety and not depression is too simple and does not reflect the more complex reality. Therefore, it might not be useful to make a distinction between anxiety and depression when considering signs of hyperarousal in the general population. This study investigated individuals from the general population. Findings might be different in clinical samples with participants with more severe problems. If, however, findings would be similar in

clinical samples, this might imply that, although effective, ingredients of treatment protocols for specifically anxiety disorders that pertain to reducing hyperarousal to diminish anxiety levels might lack a scientific rationale. This, as said, does not mean that such ingredients are ineffective. It could even be the case that they might be helpful to tackle other types of problems as well. In any case, more research is needed to further unravel the specific associations between arousal and anxiety versus depression in samples with higher problem levels.

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