

Differential parenting and risk for psychopathology: a monozygotic twin difference approach

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Abstract

Purpose Consistent and non-specific associations have been found between parenting style and major depression, anxiety disorders, and externalizing behavior. Although often considered part of twins' shared environment, parenting can also be conceptualized as non-shared environment. Non-shared environmental influences have important effects on development but are difficult to test and sort out because of the possible confounding effects of gene-environment interactions and evocative gene-environment correlations. The monozygotic (MZ) differences approach is one way to analytically investigate non-shared environment.

Methods The aim of the present study is to use the MZ differences approach to investigate the relationship between differential parenting among 1303 twin pairs (mean age 36.69 ± 8.56) and differences in total symptom counts of major depression (MD), generalized anxiety disorder (GAD), conduct disorder (CD), and anti-social behavior (ASB) during adulthood.

Results Although effect sizes tended to be small, a number of results were significantly different from zero. Perceived differences in parental coldness was positively associated with internalizing disorders. Differences in protectiveness were negatively associated with MD, GAD, and ASB. Differences in authoritarianism were positively associated with MD and CD, but negatively associated with ASB.

Conclusions Perceived differences in parenting style are associated with differences in MD, GAD, CD, and ASB outcomes in a sample of MZ twins. Despite the lack of a basis for making causal inferences about parenting style and psychopathology, these results are suggestive of such a relationship and show that non-shared environmental influence of parenting does in some cases significantly predict adult psychopathology.

Keywords Non-shared environment · Differential parenting · Psychopathology · MZ twin differences

Introduction

The relationship between perceived parenting style and risk for adult psychopathology has been well established. Consistent associations have been found between perceived parenting and major depression [1–4], anxiety disorders [5–7], and externalizing behavior [8]. These associations appear to be non-specific. For example, parenting, particularly levels of coldness, is related to a wide variety of adult psychopathology in both males and females in a non-specific way among a nationally representative U.S. sample [9] and in a twin sample [2, 10].

However, parents can treat their children quite differently. Differential parenting can even occur among monozygotic (MZ) and dizygotic (DZ) twins. Unique experiences that tend to make each twin different from one another are referred to as non-shared environmental influences and are an important source contributing to development [11, 12]. Despite this importance, testing of non-shared environmental influences can be challenging due to the complex relationship between genes and environment [13, 14]. For example, it is possible that a child's genetic

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make-up interacts with the environment in such a way that affects his or her behavior or evokes certain responses from parents. One way to analytically investigate non-shared environment is to use a MZ within twin pair differences approach. Because reared-together MZ twins share 100 % of their genes at birth and their rearing environment, the analysis of relationships between differences in behavior and the development of psychopathology can be more readily linked to the non-shared environmental influences [15]. A main strength of this design is that it provides a basis for examining non-shared environmental effects that are theoretically unconfounded from gene-environment interactions or evocative gene-environment correlation [16].

Significant associations have been found between differential parenting and differences in behavior using the MZ differences approach. For example, differences in parental discipline and parental feelings were associated with differences in levels of anxiety, pro-social behavior, hyperactivity, and conduct problems in sample of MZ twins at 4 years of age with modest effect sizes. However, at the extreme ends of the distribution, the effect size was considerably larger [15]. Negative parental discipline (e.g., smacking and shouting) has also been identified as a non-shared environmental risk factor for the development of conduct problems from childhood to early adolescence [16]. Similarly, differences in parental negativity are associated with MZ differences in anti-social behavior among adolescents [17]. Finally, twins who received less maternal warmth and more negativity during middle childhood showed more behavioral problems than their co-twins [18, 19].

While there have been some studies showing that differential parenting is associated with behavior problems in childhood and adolescence, there have been few studies that have used the MZ differences approach to determine if differences in parenting styles during childhood lead to increased risk for psychopathology in adulthood. Such an approach provides a way to account for genetic and shared environmental influences while isolating the effects of the non-shared environment. Therefore, the aim of the present study is to investigate the relationship between perceived differences in parenting styles among MZ twins and their reported differences in lifetime symptom counts of major depressive disorder (MD), generalized anxiety disorder (GAD), conduct disorder (CD), and anti-social behavior (ASB) in adulthood.

Method

Participants

The sample for these analyses were obtained from the Virginia Adult Twin Study of Psychiatric and Substance

Use Disorders (VATSPSUD), a population-based longitudinal study of Caucasian twins from the Virginia Twin Registry (now the Mid-Atlantic Twin Registry; for details, see Kendler and Prescott [20]). Male twin pairs were eligible to participate if they were born between 1940 and 1974. Female twin pairs were eligible if they were born between 1934 and 1974, and both members of the pair previously responded to a mailed questionnaire. All participants provided verbal consent for telephone interviews and written consent for in-person interviews. The study was approved by Virginia Commonwealth University's Institutional Review Board.

The present analyses used data from 1303 complete MZ twin pairs, of which 706 were male pairs and 597 were female pairs. The mean age at the time of interview was 36.69 ± 8.56 . Information about parenting, depression symptoms, and anxiety symptoms were obtained via in-person interviews by trained interviewers with a Master's degree in a mental health-related field or a Bachelor's degree with at least 2 years of clinical experience. Interviewers had no prior contact with the families. Due to potential reporting bias, information about CD and ASB was obtained via a self-report questionnaire.

Assessment of parenting

Perception of both maternal and paternal parenting was assessed for each twin using a 16-item version of the Parental Bonding Instrument (PBI; [21]). Due to the length of the interview, nine items from the original 25-item scale were dropped (using original numbering, items 2, 3, 6, 10, 14, 20, 22, and 24). Each twin was also asked to report on the parenting of his or her co-twin, and the pronouns in the items were changed accordingly. A final change to the original PBI was that the response options were modified from "very like," "moderately like," "moderately unlike," and "very unlike," to "a lot like," "somewhat like," "a little like," and "not at all like."

Because we had an a priori hypothesis about the factor structure, we initially conducted an item confirmatory factor analysis (CFA) in Mplus with three factors. Model fits for these CFAs were at the lower end of the recommended acceptable fit range (e.g., CFI between 0.86 and 0.90, and RMSEA between 0.10 and 0.12). We then conducted exploratory factor analyses (EFA) extracting one, two, and three factors for the 16 PBI parenting items. The three-factor solutions produced the most acceptable fit indexes (e.g., CFI ranged between 0.95 and 0.98 with RMSEA values of 0.06 and 0.07) for all analyses (see Table 1 for the EFA solution). EFA solutions are much less restricted than the simple structure CFA and thus should

Table 1 EFA factor loadings for twins' report of mother's parenting style (co-twin)

	Factor 1 Coldness	Factor 2 Protectiveness	Factor 3 Authoritarianism
"Spoke to you in a warm and friendly voice"	0.742 (0.753)	−0.057 (−0.021)	0.168 (0.299)
"Seemed emotionally cold to you"	0.709 (0.654)	−0.245 (−0.343)	−0.002 (0.003)
"Appeared to understand your problems and worries"	0.669 (0.664)	−0.003 (0.014)	0.292 (0.366)
"Enjoyed talking things over with you"	0.685 (0.682)	0.020 (0.009)	0.264 (0.359)
"Frequently smiled at you"	0.735 (0.750)	−0.011 (−0.025)	0.196 (0.290)
"Could make you feel better when you were upset"	0.727 (0.687)	0.021 (0.029)	0.249 (0.344)
"Did not talk to you very much"	0.630 (0.628)	−0.280 (−0.347)	−0.069 (−0.030)
"Did not want you to grow up"	0.142 (0.090)	0.674 (0.738)	−0.029 (−0.007)
"Tried to control everything you did"	−0.043 (−0.019)	0.573 (0.675)	−0.339 (−0.265)
"Tended to baby you"	0.442 (0.285)	0.642 (0.725)	0.051 (0.073)
"Tried to make you dependent on her/him"	0.000 (−0.001)	0.729 (0.757)	−0.160 (−0.041)
"Was overprotective of you"	0.320 (0.219)	0.700 (0.788)	−0.169 (−0.034)
"Liked you to make your own decisions"	0.030 (0.045)	−0.149 (−0.232)	0.707 (0.742)
"Let you decide things for yourself"	−0.002 (−0.019)	−0.169 (−0.204)	0.775 (0.794)
"Gave you as much freedom as you wanted"	−0.141 (−0.156)	−0.012 (−0.016)	0.735 (0.736)
"Let you dress in a way you pleased"	−0.128 (−0.134)	0.079 (0.058)	0.597 (0.604)

Dominant loadings for each of the three factors are in bold

The factor solution was obtained using a GEOMIN oblique rotation

provide better overall indexes of fit. In combination, the CFA and EFA results provide evidence for the three different parenting dimensions of the PBI items and the creation of item sum scores for the MZ difference analyses (coldness, protectiveness, and authoritarianism). This factor structure has also been widely replicated [2, 10, 22].

Coldness was conceptualized as low levels of warmth, caring, and lovingness (items 1, 4, 5, 11, 12, 17, and 18). Protectiveness reflected an overprotective and controlling style of parenting (items 8, 9, 13, 19, and 23). Finally, authoritarianism was characterized as discouragement of autonomy and independence (items 7, 15, 21, and 25). Based on the item factor analytic results, sum scores of the items found to be markers of each of the parenting style dimensions were created for both self-report and co-twin reports. Using these sum scores, within twin difference scores (i.e., twin 1 minus twin 2) were calculated for all complete twin pairs. Estimates of intra-class correlations showed consistent patterns across the twin and co-twin reports, with reports of maternal coldness having the highest intra-class correlation (twin: $r = 0.61$; co-twin: $r = 0.51$), then reports of maternal protectiveness (twin: $r = 0.51$; co-twin: $r = 0.39$), and reports of maternal authoritarianism having the lowest correlation (twin: $r = 0.45$; co-twin: $r = 0.38$). This patterning was similar for reports of paternal parenting styles.

Symptom counts of psychopathology

Responses to individual DSM-III-R symptom criteria for MD and GAD were obtained via personal interview using the SCID interview [23]. The interview was separated into different sections for recording symptomatology that was experienced over the last year versus lifetime minus the last year. For a symptom to be recorded as "present/positive," only those symptoms that co-occurred temporally were considered in order to meet the definition of a disorder syndrome. Using a lifetime period framework, the presence/absence of each symptom criteria for last year and lifetime minus last year symptom was determined and then used to create a total symptom count of these binary lifetime symptom variables. Within pair twin 1 minus twin 2 difference scores were then calculated for complete pairs.

Responses to individual DSM-III-R symptom criteria for CD and ASB were obtained via self-report. CD was assessed separately for ages 14 and younger and ages 15–17, but was aggregated for the purpose of the present analyses. ASB was assessed for ages over 18.

Statistical analyses

Univariate and multivariate linear regression models were fitted to the within twin pair difference scores of the three parenting styles and four disorder symptom counts. The co-twin reporting difference scores for parenting styles were also used as predictors in the regression models to assess any possible bias due to self-reporting and recall bias. Models were fit without intercepts because both the

independent and dependent variables are defined as difference scores between members of a twin pair [24]. Models were also fit that included an interaction term without the corresponding direct effects for age and sex as this is a more appropriate way to fit and interpret covariate effects obtained using a within pair MZ difference design (e.g., maternal coldness by age and maternal coldness by sex; [24]).

Results

Results from the univariate linear regression analyses are presented in Table 2. These results need to be interpreted from the perspective of within pair twin differences. Thus, twin differences in parenting style predict an increased difference in symptom counts when the beta is positive. Likewise, differences in parenting style predict a decreased difference in symptom counts when the beta is negative. Although in our final models information about between twin differences is not used in the MZ differences approach, an advantage is that confounding effects of genetic and shared environmental influences are effectively controlled for. However, an attempt was made to analyze between twin differences by including interactions in the regression models defined by the product of the twin pair sum scores of parenting and the parenting difference scores. These results produced only one significant interaction (paternal coldness on MD: $\beta = 0.002$, $SE = 0.01$, $p = 0.033$). Effect size estimates from these models including the between-within interaction term were not noticeably altered from the estimates obtained without this interaction term. This single significant finding could be due to chance based on the number of tests conducted. Accordingly, these between twin effects do not seem to be important predictors of adult psychopathology.

The within twin effects yielded a number of significant findings, although effect sizes tended to be small. First, perceived differences of paternal coldness, maternal authoritarianism, and paternal authoritarianism predicted an increase in the within pair twin difference in MD symptom counts. However, differences in protectiveness showed a decrease. Second, for GAD, differences in maternal and paternal coldness displayed an increase in the difference in symptom counts, while differences in protectiveness were found to decrease. Third, for CD, differences in paternal authoritarianism showed an increase in the difference in symptom counts. Finally, for ASB, differences in both maternal and paternal protectiveness as well as differences in maternal authoritarianism were related to a decreased difference in symptom counts.

The only significant age interactions were maternal coldness by age ($\beta = -0.007$, $SE = 0.02$, $p = 0.02$) and

Table 2 Parenting styles as predictors of psychopathology (univariate)

	β (SE)	p	Adj. R^2
MD SX difference score			
Maternal			
Coldness	0.042 (0.03)	0.1300	0.001
Protectiveness	-0.085 (0.03)	0.0020*	0.007
Authoritarianism	0.130 (0.04)	0.0005*	0.009
Paternal			
Coldness	0.087 (0.02)	0.0004*	0.010
Protectiveness	-0.107 (0.03)	0.0009*	0.009
Authoritarianism	0.108 (0.03)	0.004*	0.006
GAD SX difference score			
Maternal			
Coldness	0.100 (0.04)	0.009*	0.005
Protectiveness	-0.093 (0.04)	0.013*	0.004
Authoritarianism	-0.076 (0.05)	0.137	0.001
Paternal			
Coldness	0.070 (0.03)	0.033*	0.003
Protectiveness	-0.125 (0.04)	0.004*	0.006
Authoritarianism	0.083 (0.05)	0.105	0.001
CD SX difference score			
Maternal			
Coldness	0.044 (0.03)	0.112	0.002
Protectiveness	-0.033 (0.03)	0.223	0.001
Authoritarianism	-0.066 (0.04)	0.079	0.002
Paternal			
Coldness	0.036 (0.02)	0.136	0.001
Protectiveness	-0.042 (0.03)	0.200	0.001
Authoritarianism	0.098 (0.04)	0.006*	0.007
ASB SX difference score			
Maternal			
Coldness	0.009 (0.03)	0.759	-0.001
Protectiveness	-0.086 (0.03)	0.001*	0.010
Authoritarianism	-0.088 (0.04)	0.011*	0.005
Paternal			
Coldness	0.034 (0.02)	0.149	0.001
Protectiveness	-0.078 (0.03)	0.016*	0.005
Authoritarianism	0.042 (0.04)	0.256	0.001

Significant p values are marked with an asterisk (*)

paternal coldness by age ($\beta = -0.007$, $SE = 0.003$, $p = 0.014$), both for CD. However, this may be because the CD symptoms were restricted to the teenage years. The only significant sex interactions were maternal coldness by sex ($\beta = -0.228$, $SE = 0.08$, $p = 0.003$), maternal authoritarianism by sex ($\beta = -0.369$, $SE = 0.10$, $p = 0.0004$), and paternal authoritarianism by sex ($\beta = -0.318$, $SE = 0.10$, $p = 0.002$), all for GAD (Fig. 1), also with relatively small effect sizes. The negative betas indicate that the difference scores for females are

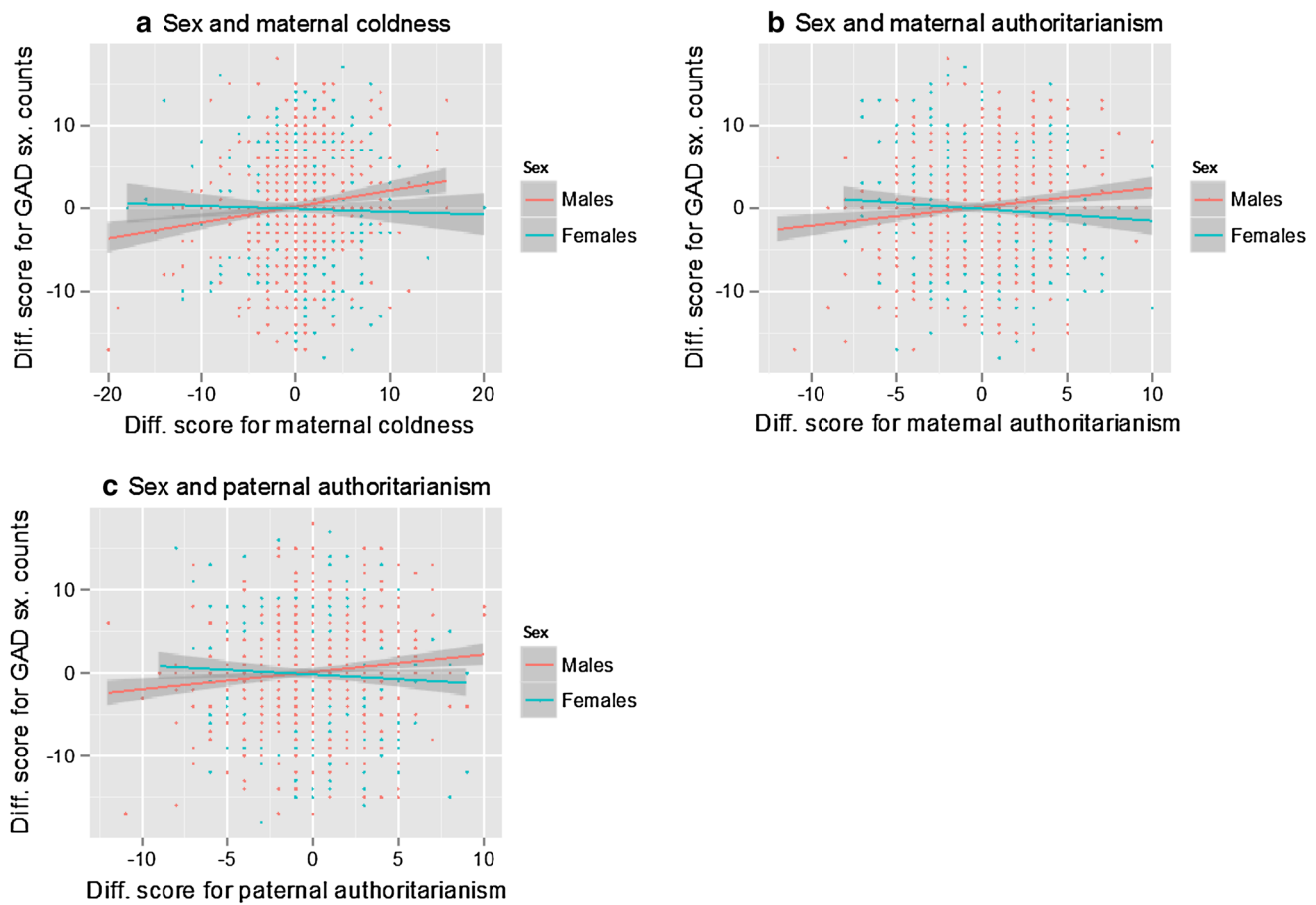


Fig. 1 Sex interactions for GAD

more similar than the difference scores for males, suggesting that males may be more prone to GAD as a result of these parenting styles.

The results of the univariate linear regression analyses for the co-twin reports are presented in Table 3. All of the results for MD and CD are consistent with the twin self-report findings. For GAD, only paternal coldness was no longer significant. For ASB, maternal authoritarianism and paternal protectiveness lost significance. Since the results using self-report and co-twin reports were consistent, it is less likely that the results were influenced by reporting and recall bias.

Because the predictors were correlated, we also ran multivariate analyses with the three parenting styles for each parent included in each model for MD, GAD, CD, and ASB. These results are displayed in Table 4. Again, the results are quite similar and consistent with the univariate results. Differences in paternal coldness and maternal authoritarianism still increased the difference in symptom counts of MD, but paternal authoritarianism was no longer significant. Both maternal and paternal protectiveness still showed a decrease in the difference of MD symptom counts. For GAD, differences in both maternal and paternal

protectiveness still resulted in decreases in the difference in symptom counts. Only maternal coldness increased the difference and paternal coldness was not significant. Differences in paternal authoritarianism still increased the difference in symptom counts of CD. Finally, for ASB, differences in both maternal and paternal protectiveness decreased the difference in symptom counts, but maternal authoritarianism was no longer significant.

Discussion

The non-shared environment is an important developmental influence that can be difficult to test because of the complex nature of the influences of genes and the environment. The MZ twin differences design provides one approach to isolating the non-shared environment. Therefore, our goal in present study was to use this approach to examine whether perceived differences in parenting styles among MZ twins were associated with reported differences in lifetime symptom counts of MD, GAD, CD, and ASB in adulthood. Regression-modeling results indicated that perceived differences in parenting style are associated with

Table 3 Co-twin report of parenting as predictors of psychopathology

	β (SE)	p	Adj. R^2
MD SX difference score			
Maternal			
Coldness	0.054 (0.03)	0.07	0.002
Protectiveness	-0.099 (0.03)	0.0001*	0.011
Authoritarianism	0.076 (0.04)	0.038*	0.003
Paternal			
Coldness	0.065 (0.02)	0.008*	0.005
Protectiveness	-0.097 (0.03)	0.001*	0.008
Authoritarianism	0.087 (0.04)	0.016*	0.004
GAD SX difference score			
Maternal			
Coldness	0.082 (0.04)	0.045*	0.003
Protectiveness	-0.098 (0.04)	0.006*	0.005
Authoritarianism	-0.011 (0.05)	0.824	-0.0008
Paternal			
Coldness	0.029 (0.03)	0.391	-0.0002
Protectiveness	-0.110 (0.04)	0.009*	0.005
Authoritarianism	0.053 (0.05)	0.289	0.000
CD SX difference score			
Maternal			
Coldness	0.003 (0.03)	0.928	-0.001
Protectiveness	-0.043 (0.03)	0.094	0.002
Authoritarianism	0.054 (0.04)	0.133	0.001
Paternal			
Coldness	0.035 (0.02)	0.150	0.001
Protectiveness	-0.043 (0.03)	0.172	0.0010
Authoritarianism	0.095 (0.04)	0.007*	0.007
ASB SX difference score			
Maternal			
Coldness	-0.001 (0.03)	0.981	-0.001
Protectiveness	-0.054 (0.03)	0.040*	0.004
Authoritarianism	0.049 (0.04)	0.181	0.001
Paternal			
Coldness	0.031 (0.02)	0.200	0.0007
Protectiveness	-0.045 (0.03)	0.154	0.0120
Authoritarianism	0.048 (0.04)	0.175	0.0009

Significant p values are marked with an asterisk (*)

Table 4 Parenting as predictors of psychopathology (multivariate)

	β (SE)	p	Adj. R^2
MD SX difference score			
Maternal			
Coldness	0.022 (0.03)	0.447	0.013
Protectiveness	-0.063 (0.03)	0.026*	0.013
Authoritarianism	0.107 (0.04)	0.006*	0.013
Paternal			
Coldness	0.078 (0.03)	0.003*	0.021
Protectiveness	-0.095 (0.03)	0.004*	0.021
Authoritarianism	0.056 (0.04)	0.158	0.021
GAD SX difference score			
Maternal			
Coldness	0.091 (0.04)	0.021*	0.008
Protectiveness	-0.078 (0.04)	0.043*	0.008
Authoritarianism	0.027 (0.05)	0.622	0.008
Paternal			
Coldness	0.060 (0.04)	0.093	0.008
Protectiveness	-0.117 (0.04)	0.009*	0.008
Authoritarianism	0.035 (0.05)	0.528	0.008
CD SX difference score			
Maternal			
Coldness	0.037 (0.03)	0.196	0.003
Protectiveness	-0.024 (0.03)	0.387	0.003
Authoritarianism	0.047 (0.04)	0.237	0.003
Paternal			
Coldness	0.025 (0.03)	0.329	0.006
Protectiveness	-0.005 (0.03)	0.885	0.006
Authoritarianism	0.084 (0.04)	0.021*	0.006
ASB SX difference score			
Maternal			
Coldness	-0.006 (0.03)	0.839	0.011
Protectiveness	-0.075 (0.03)	0.007*	0.011
Authoritarianism	0.070 (0.04)	0.078	0.011
Paternal			
Coldness	0.034 (0.03)	0.189	0.006
Protectiveness	-0.071 (0.03)	0.033*	0.006
Authoritarianism	0.015 (0.04)	0.701	0.006

Significant p values are marked with an asterisk (*)

psychopathology in adulthood, accounting for genetic background. Our findings are consistent with previous research, which has consistently shown relationships between parenting style and adult psychopathology [1–10].

Specifically, we found a number of statistically significant results for each of the parenting constructs, albeit of small effect size. First, within twin pair differences in

perceived coldness during childhood was positively related to within pair differences for internalizing disorders as adults. Parental coldness experienced as a child has been consistently linked to the development of a wide range of psychopathology in adulthood [2–4, 9, 10]. Our findings suggest that this association remains even when controlling for genetic risk factors, which is consistent with previous research using a similar approach to predict differential development of externalizing problems in middle

childhood among twins [16, 18, 19]. Because the deleterious effect of coldness has been the most consistently replicated result across time, future research could investigate how interventions can increase parental warmth.

Second, within twin pair differences in protectiveness were negatively related to within pair differences for MD, GAD, and ASB, suggesting that over-protectiveness may shield against both internalizing and externalizing problems in adulthood. This finding is incongruent with previous research showing that protectiveness increased risk for MD and GAD [3, 10]. However, it is consistent with prior work that has found that protectiveness reduces risk for externalizing disorders [9, 22]. Determining whether over-protectiveness is a risk factor or a protective factor for the development of adult psychopathology, as well as the degree of the protectiveness, could be an important area for future research, given the inconsistent research findings. The resolution may help to inform programming for parent training classes, as it can teach parents the ideal amount of freedom and protection they should provide to their children.

Finally, within twin pair differences in authoritarianism were positively related to within pair differences for MD and CD, but were negatively related to ASB. These results may suggest that authoritarianism increases risk for MD and CD, consistent with previous research [8, 9, 16], while an authoritarian parenting style may have a protective effect long-term against the development of ASB. While this finding is seemingly contradictory to previous findings showing increased risk for ASB [16, 18, 19], these studies only assessed conduct problems and anti-social behavior during childhood and adolescence, while our assessment was of adults. Because our measure of CD was based on recall of behavior during the years of age 17 and younger and our measure of ASB was for adults over the age of 18, one possible explanation for our results is that an authoritarian parenting style may initially cause children to act out and display symptoms of CD. Then, over time, the effect of this parenting style becomes more of a protective buffer against the long-term threat of developing ASB. Future research could help to clarify the role of authoritarianism across time.

Additional interaction analyses were also conducted to assess covariate effects of age and sex. We found significant interactions for age by maternal and paternal coldness in the prediction of CD. However, we felt that this finding could be due to CD being limited to behavior occurring only during the teenage years. An alternative explanation is that this is a true effect, such that differences in maternal and paternal coldness may have possibly varying impact across the often volatile adolescence period of development. We also showed significant sex interactions in the prediction of GAD. Our findings suggest that males might be more sensitive to the effects of maternal coldness,

maternal authoritarianism, and paternal authoritarianism, which manifests as an increased risk for GAD. This may be an important area for future research investigating the etiology of GAD in males, given that internalizing disorders are much more common in females than males [25].

Limitations and strengths

These results should be considered in the context of several possible limitations. First, the nature of the data is such that it is not possible to unambiguously sort out whether differential parenting is child-driven or parent-driven. It is possible that differential parenting may be elicited by differences in twins' behavior influenced by the environment. For example, Hou and colleagues [17] found evidence for child-driven effects such that the twin displaying higher levels of externalizing behavior was more likely to elicit hostile parenting. However, we know these cannot be driven by genetic differences. Second, other twin characteristics could be impacting the results, such as personality and birth order. Third, while the effect of parental psychopathology was not taken into account in the regression models, previous research has shown that parenting reports are not likely to be influenced by symptoms of depression (10). Fourth, although the effect sizes were generally quite small, we note that considering how complex the disorder phenotypes are along with using within twin pair differences as the unit of analysis, such small effect sizes may not be surprising. Fifth, this design includes several methodological limitations, such as shared method variance (i.e., systematic error variance due to the variables being assessed by the same method) and measurement limited to a single time point. Finally, a potential limitation of using retrospective recall of parenting practices is that it includes possible recall bias. However, previous studies have suggested that retrospective recall of parenting has sufficient reliability and validity [26, 27], as well as stability over time [28]. We also included the co-twin's report of parenting as an additional protection against recall bias. The use of the co-twin's report also addresses the issue of method variance by way of using multiple raters. Thus, the MZ co-twin difference approach to examine non-shared environmental influences has features that can offset some of these potential limitations—limitations that are present in most observational studies of psychopathology.

Despite these limitations, one of the main strengths of our data analyses is the way confounding effects of genetic and shared environmental influences can be addressed in the MZ twin difference approach. In addition, our study features a number of other methodological strengths. These include the use of a large population-based twin sample, reports from both the twin and co-twin, and the use of a structured interview to assess psychopathology.

Implications and conclusion

We have shown that the MZ differences approach provides a way to isolate the effects of parenting style as a non-shared environmental influence on the development of adult psychopathology. Our findings add to the rather sparse current literature utilizing the MZ twin difference approach to investigate the effects of parenting style. Additionally, our results further implicate the role of differential parenting as a “candidate” non-shared environmental risk factor for the development of psychopathology [15–19]. Clinically, these findings highlight the importance of positive parenting training classes and parent–child interaction therapy. These types of prevention and intervention programs can help to assist and support parents in dealing with difficult children, potentially decreasing the impact of parenting differences among twins, and potentially decreasing risk for the development of adult psychopathology.

Conflict of interest On behalf of all authors, the corresponding author states that there are no conflicts of interest.

References

- Kendler KS, Kessler RC, Neale MC, Heath AC, Eaves LJ (1993) The prediction of major depression in women: toward an integrated etiologic model. *Am J Psychiatry* 150:1139–1148
- Kendler KS, Myers J, Prescott CA (2000) Parenting and adult mood, anxiety, and substance use disorders in female twins: an epidemiological, multi-informant, retrospective study. *Psychol Med* 30:281–294
- Parker G (1979) Parental characteristics in relation to depressive disorders. *Br J Psychiatry* 134:138–147
- Parker G (1983) Parental ‘affectionless control’ as an antecedent to adult depression. A risk factor delineated. *Arch Gen Psychiatry* 40:956–960
- DiBartolo PM, Helt M (2007) Theoretical models of affectionate versus affectionless control in anxious families: a critical examination based on observations of parent-child interactions. *Clin Child Fam Psychol Rev* 10:253–274
- McLeod BD, Wood JJ, Weisz JR (2007) Examining the association between parenting and childhood anxiety: a meta-analysis. *Clin Psychol Rev* 10:253–274
- Wood JJ, McLeod BD, Sigman M, Hwang WC, Chu BC (2003) Parenting and childhood anxiety: theory, empirical findings, and future directions. *J Child Psychol Psychiatr* 44:134–151
- Rothbaum F, Weisz JR (1994) Parental caregiving and child externalizing behavior in nonclinical samples: a meta-analysis. *Psychol Bull* 116:55–74
- Enns MW, Cox BJ, Clara I (2002) Parental bonding and adult psychopathology: results from the U.S. National Comorbidity Survey. *Psychol Med* 32:997–1008
- Otowa T, Gardner CO, Kendler KS, Hettema JM (2013) Parenting and risk for mood, anxiety and substance use disorders: a study in population-based male twins. *Soc Psychiatry Psychiatr Epidemiol* 48:1841–1849
- Plomin R, Daniels D (2011) Why are children in the same family so different from one another? *Int J Epidemiol* 40:563–582
- Rowe DC (1981) Environmental and genetic influence on dimensions of perceived parenting: a twin study. *Dev Psychol* 17:203–208
- Plomin R, DeFries JC, Loehlin JC (1977) Genotype-environment interaction and correlation in the analysis of human behavior. *Psychol Bull* 84:309–322
- Rutter M, Sillberg J (2002) Gene-environment interplay in relation to emotional and behavioral disturbance. *Annu Rev Psychol* 53:463–490
- Asbury K, Dunn JF, Pike A, Plomin R (2003) Nonshared environmental influences on individual differences in early behavioral development: a monozygotic twin differences study. *Child Dev* 74:933–943
- Viding E, Fontaine N, Oliver BR, Plomin R (2009) Negative parental discipline, conduct problems, and callous-unemotional traits: monozygotic twin differences study. *Br J Psychiatry* 195:414–419
- Hou J, Chen Z, Natsuaki MN, Li X, Yang X, Zhang J, Zhang J (2013) A longitudinal investigation of the associations among parenting, deviant peer affiliation, and externalizing behaviors: a monozygotic twin differences design. *Twin Res Hum Genet* 16:698–706
- Caspi A, Moffitt TE, Morgan J et al (2004) Maternal expression emotion predicts children’s antisocial behavior problems: using monozygotic-twin differences to identify environmental effects on behavioral development. *Dev Psychol* 40:149–160
- Mullineaux PY, Deater-Deckard K, Petrill SA, Thompson LA (2009) Parenting and child behavior problems: a longitudinal analysis of non-shared environment. *Infant Child Dev* 18:133–148
- Kendler KS, Prescott CA (2006) Genes, environment and psychopathology: understanding the causes of psychiatric and substance use disorders. The Guildford Press, New York
- Parker G, Tupling H, Brown LB (1979) A parental bonding instrument. *Br J Med Psychol* 52:1–10
- Gao J, Li Y, Cai Y et al (2011) Perceived parenting and risk for major depression in Chinese women. *Psychol Med* 42:921–930
- Spitzer RL, Williams JBW (1985) Structured clinical interview for DSM-III-R (SCID). Biometrics Research Department, New York State Psychiatric Institute, New York
- Carlin JB, Gurrin LC, Sterne J, Morley R, Dwyer T (2005) Regression models for twin studies: a critical review. *Int J Epidemiol* 34:1089–1099
- Kessler RC, McGonagle K, Zhao S, Nelson CB, Hughes M, Eshleman S, Wittchen HU, Kendler KS (1994) Lifetime and 12-month prevalence of DSM-III-R psychiatric disorders in the United States: results from the National Comorbidity Survey. *Arch Gen Psychiatry* 51:8–19
- McCrae RR, Costa PT (1988) Do parental influences matter? *J Pers* 56:445–449
- Parker G (1989) The parental bonding instrument: psychometric properties reviewed. *Psychiatr Dev* 4:317–335
- Wilhelm K, Niven H, Parker G, Hadzi-Pavlovic D (2005) The stability of the parental bonding instrument over a 20-year period. *Psychol Med* 35:387–393