**Supplemental Information**

**Genetic Versus Environmental Influences on Callous-Unemotional Traits in Pre-Adolescence: The Role of Parenting and Parental Psychopathology**

**Supplemental Results**

*Etiological models specifying full ACE decomposing on CU traits, perceived parental acceptance, and perceived family conflict.* Results from the ACE variance decomposition of CU traits and parental acceptance showed acceptable model fit (CFI=.93, TLI=.95, RMSEA=.04 [90% CI, .01-.09]). Model fit was also good for the ACE variance decomposition of CU traits and family conflict (CFI=.96, TLI=.97, RMSEA=.03 [90% CI, .00-.06]) (see **Table S10)**. Bivariate estimates revealed the association between higher CU traits and lower parental acceptance was due to shared environmental factors (26%, C=-.51, 95% CI [-.77, -.25]). Likewise, the association between perceived family conflict and CU traits was due to shared environmental factors (13%, C= .36, 95% CI [.07, .66]).

We next examined whether parental acceptance and family conflict moderated the etiology of CU traits using the extended G × E interaction model (**Table S11**). Results suggested that non-shared environmental influences on CU traits varied as a function of parental acceptance – specifically that non-shared environmental influences on CU traits were stronger among children who reported lower levels of parental acceptance (E1= -.07; *p*<.01) (see **Table S12**). In contrast, regarding moderation by perceived family conflict, we found that a no moderation model fit the data best (see **Table S11**).

Finally, we examined whether parental psychopathology moderated the etiology of CU traits using a univariate G × E model.

**Table S1.** Cross-trait, cross-twin correlations by MZ and DZ twins

|  |
| --- |
| **Monozygotic Twin****Pairs** |
| *Variable* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 1. CU traits T1 | -- |  |  |  |  |  |  |  |
| 2. CU traits T2 | .48\*\*\* | -- |  |  |  |  |  |  |
| 3. CP T1 | .35\*\*\* | .21\*\*\* | -- |  |  |  |  |  |
| 4. CP T2 | .25\*\*\* | .32\*\*\* | .68\*\*\* | -- |  |  |  |  |
| 5. Acceptance T1 | -.19\*\*\* | -.09 | -.05 | -.12\* | -- |  |  |  |
| 6. Acceptance T2 | -.16\*\*\* | -.15\*\* | -.09 | -.10 | .35\*\*\* | -- |  |  |
| 7. Family Conflict T1 | .19\*\*\* | .15\*\* | .17\*\*\* | .15\*\* | -.358\*\* | -.24\*\*\* | -- |  |
| 8. Family Conflict T2 | .11\* | .12\* | .16\*\* | .14\*\* | -.268\*\* | -.27\*\*\* | .36\*\*\* | -- |
| **Dizygotic Twin Pairs** |
| *Variable* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 1. CU traits T1 | -- |  |  |  |  |  |  |  |
| 2. CU traits T2 | .26\*\*\* | -- |  |  |  |  |  |  |
| 3. CP T1 | .56\*\*\* | .17\*\*\* | -- |  |  |  |  |  |
| 4. CP T2 | .26\*\*\* | .45\*\*\* | .41\*\* | -- |  |  |  |  |
| 5. Acceptance T1 | -.08 | -.04 | -.004 | -.07 | -- |  |  |  |
| 6. Acceptance T2 | -.11\* | -.12\*\* | -.06 | -.16\*\* | .28\*\*\* | -- |  |  |
| 7. Family Conflict T1 | .13\*\* | .09 | .18\*\*\* | .12\* | -.22\*\*\* | -.13\*\* | -- |  |
| 8. Family Conflict T2 | .19\*\*\* | .08 | .11\* | .19\*\*\* | -.08 | -.17\*\*\* | .23\*\*\* | -- |

*Note*. CU= Callous Unemotional; CP= Conduct Problems; Acceptance= Parental Acceptance; Sex= 0 for male, 1 for female; MZ= Monozygotic; DZ= Dizygotic; T1= Twin 1; T2= Twin 2.This table presents correlations using the un-transformed CU traits variable. *p*< .05\*, *p*<.01\*\*, *p*<.001\*\*\*

**Table S2.** Bivariate ACE models of CU traits without controlling for CP and each child reported parenting environment factor [with 95% CIs]

|  |  |  |
| --- | --- | --- |
|  | **Proportion with 95% CI** |  |
|  | CU Traits | Acceptance | Total (%) |
| *Additive genetic effect (a2)* |  |  |  |
| CU Traits | **.70 [.62, .77]** | -- | 49% |
| Acceptance | -- | -- |  |
| *Shared environmental effect (c2)* |  |  |  |
| CU Traits | -- | -- | -- |
| Acceptance | -- | **.50 [.41, .58]** | 25% |
| *Non-shared environmental effect (e2)* |  |  |  |
| CU Traits | **.72 [.64, .79]** | -- | 51% |
| Acceptance | **-.08 [-.15, -.01]** | **.86 [.81, .91]** | 75% |
|  | CU Traits | Family Conflict | Total (%) |
| *Additive genetic effect (a2)* |  |  |  |
| CU Traits | **.70 [.62, .77]** | -- | 49% |
| Family Conflict | .**22 [.11, .32]** | -.33 [-.56, .000] | 16% |
| *Shared environmental effect (c2)* |  |  |  |
| CU Traits | -- | -- | -- |
| Family Conflict | -- | .35 [.000, .50] | 12% |
| *Non-shared environmental effect (e2)* |  |  |  |
| CU Traits | **.72 [.64, .78]** | -- | 51% |
| Family Conflict | **-.10 [-.18, -.003]** | **.85 [.78, .90]** | 72% |
| *Note.* CU= Callous Unemotional. The bivariate model of CU traits and parental acceptance showed acceptable model fit well (CFI = .93, TLI= .96, RMSEA = .04 [90% C.I.=.000-.06]), as did the model of CU traits and family conflict (CFI = .97, TLI= .98, RMSEA = .03 [90% C.I.=.000-.05]). Bolded estimates contain 95% confidence intervals that do not overlap with zero. Confidence intervals were derived from 10,000 bootstrap draws. |

**Table S3.** G × E model (Purcell and Extended) fit statistics for CU trait models controlling for CP

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Models** | **N (MZ/DZ)** | **Log Likelihood (df)** | **Δ ⎯ 2LL** | **AIC** | **BIC** | **SBIC** |
| *Test Model: AE* | *Test Model: A* | *Test Model: E* |
| **Parental Acceptance**  |  |  |  |  |  |  |  |  |
| **AE** | **770 (336/434)** | **-1985.18 (10)** | **--** | **--** | **--** | **3990.35** | **4036.82** | **4005.06** |
| E | 770 (336/434) | -2215.04 (9) | 459.72, *p*<.001 | -- | -- | 4448.07 | 4489.89 | 4461.31 |
| No Moderation | 770 (336/434) | -1991.93 (8) | 13.52, *p*<.01 | -- | *NA\** | 3999.87 | 4037.04 | 4011.64 |
| **Family Conflict** |  |  |  |  |  |  |  |  |
| AE | 770 (336/434) | -2317.52 (10) | -- | **--** | **--** | 4655.03 | 4701.50 | 4669.74 |
| A | 770 (336/434) | -1993.44 (9) | *NA\** | -- | -- | 4004.88 | 4046.70 | 4018.12 |
| E | 770 (336/434) | -1993.82 (9) | *NA\** | -- | -- | 4005.65 | 4047.46 | 4018.89 |
| **No Moderation** | **770 (336/434)** | **-1994.36 (8)** | ***NA\**** | **1.84, *p*= .17** | **.76, , *p*= .38** | **4004.73** | **4041.90** | **4016.49** |
| **Parental Psychopathology** |  |  |  |  |  |  |  |  |
| AE | 729 (315/414) | -1986.72 (6) | -- | -- | -- | 3985.43 | 4012.98 | 3993.93 |
| **E** | **729 (315/414)** | **-1987.64 (5)** | **1.84, *p*= .17** | **--** | **--** | **3985.27** | **4008.23** | **3992.36** |
| No Moderation | 729 (315/414) | -2001.98 (4) | 30.53, *p*<.001 | -- | 28.69, *p*<.001 | 4011.96 | 4030.33 | 4017.63 |

*Note.* Nested models were compared using likelihood-ratio tests of nested models. If the nested model’s 2 log-likelihood differed significantly from the more complex model the nested model’s fit was judged to be significantly worse and the more complex model was retained. The best-fitting model is indicated in bold*.* \*When model fitting of the least restrictive model (i.e., the model with more parameters) was poor we did not conduct likelihood-ratio tests.

Δ ⎯ 2LL= Difference in ⎯ 2LL(twice the negative loglikelihood) between the present model and the model that is tested; AIC= Akaike’s information criterion; BIC= Bayesian information criterion; SBIC= Schwarz information criterion; CU= callous Unemotional; CP= conduct Problems; A= additive genetic effect; E= non-shared environmental effect. *p<.05\*, p<.01\*\*, p<.001\*\*\**

**Table S4.** G × E model (Purcell and Extended) fit statistics for CU trait models without controlling for CP

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Models** | **N (MZ/DZ)** | **Log Likelihood (df)** | **Δ ⎯ 2LL** | **AIC** | **BIC** | **SBIC** |
| *Test Model: AE* | *Test Model: A* | *Test Model: E* |
| **Parental Acceptance**  |  |  |  |  |  |  |  |  |
| **AE** | **770 (336/434)** | **-1977.18 (10)** | **--** | **--** | **--** | **3974.36** | **4020.82** | **3989.07** |
| E | 770 (336/434) | -2194.83 (9) | 446.97, *p*<.001 | -- | -- | 4407.67 | 4449.49 | 4420.91 |
| No Moderation | 770 (336/434) | -1981.73 (8) | 9.10, *p*<.05 | -- | *NA\** | 3979.46 | 4016.63 | 3991.23 |
| **Family Conflict** |  |  |  |  |  |  |  |  |
| AE | 770 (336/434) | -2280.96 (10) | -- | -- | -- | 4581.92 | 4628.38 | 4596.63 |
| A | 770 (336/434) | -1976.30 (9) | *NA\** | -- | -- | 3970.60 | 4012.42 | 3983.84 |
| **E** | **770 (336/434)** | **-1975.50 (9)** | ***NA\**** | **--** | **--** | **3969.00** | **4010.82** | **3982.24** |
| No Moderation | 770 (336/434) | -1978.43 (8) | *NA\** | 4.25, *p*<.05 | 5.85, *p*<.05 | 3972.85 | 4010.02 | 3984.62 |
| **Parental Psychopathology** |  |  |  |  |  |  |  |  |
| **AE** | **729 (315/414)** | **-1949.85 (6)** | **--** | **--** | **--** | **3911.70** | **3939.25** | **3920.20** |
| E | 729 (315/414) | -1951.84 (5) | 3.98, *p*<.05 | -- | -- | 3913.68 | 3936.64 | 3920.76 |
| No Moderation | 729 (315/414) | -1971.39(4) | 43.08, *p*<.001 | -- | 39.10, *p*<.001 | 3950.78 | 3969.15 | 3956.45 |

*Note.* Nested models were compared using likelihood-ratio tests of nested models. If the nested model’s 2 log-likelihood differed significantly from the more complex model the nested model’s fit was judged to be significantly worse and the more complex model was retained. The best-fitting model is indicated in bold*.* \*When model fitting of the least restrictive model (i.e., the model with more parameters) was poor we did not conduct likelihood-ratio tests.

Δ ⎯ 2LL= Difference in ⎯ 2LL(twice the negative loglikelihood) between the present model and the model that is tested; AIC= Akaike’s information criterion; BIC= Bayesian information criterion; SBIC= Schwarz information criterion; CU= callous Unemotional; CP= conduct Problems; A= additive genetic effect; E= non-shared environmental effect. *p<.05\*, p<.01\*\*, p<.001\*\*\**

**Table S5.** G × E model (Purcell and Extended) fit statistics of CU traits controlling for CP; un-residualized parental acceptance, family conflict, and parental externalizing and internalizing problems

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Models** | **N (MZ/DZ)** | **Log Likelihood (df)** | **Δ ⎯ 2LL** | **AIC** | **BIC** | **SBIC** |
| *Test Model: AE* | *Test Model: A* | *Test Model: E* |
| **Parental Acceptance**  |  |  |  |  |  |  |  |  |
| AE | 770 (336/434) | -2138.60 (10) | -- | -- | -- | 4297.20 | 4343.66 | 4311.91 |
| A | 770 (336/434) | -1988.77 (9) | *NA\** | -- | -- | 3995.53 | 4037.35 | 4008.77 |
| E | 770 (336/434) | -2174.97 (9) | 72.74, *p<.001* | -- | -- | 4367.95 | 4409.76 | 4381.19 |
| **No Moderation** | **770 (336/434)** | **-1990.15 (8)** | ***NA\**** | **2.78, *p*= .10** | ***NA\**** | **3996.31** | **4033.48** | **4008.08** |
| **Family Conflict** |  |  |  |  |  |  |  |  |
| AE | 771 (337/434) | -2310.19 (10) | -- | -- | -- | 4640.37 | 4686.85 | 4655.09 |
| **A** | **771 (337/434)** | **-1992.02 (9)** | *NA\** | **--** | **--** | **4002.05** | **4043.88** | **4015.30** |
| E | 771 (337/434) | -2334.802 (9) | 49.23, *p<.001* | -- | -- | 4687.60 | 4729.43 | 4700.85 |
| No Moderation | 771 (337/434) | -1994.11 (8) | *NA\** | 4.18, *p*<.05 | -681.38, *p*= 1 | 4004.22 | 4041.41 | 4016.00 |
| **Parental Externalizing Problems** |  |  |  |  |  |  |  |  |
| **AE** | **729 (315/414)** | **-1991.37 (6)** | **--** | **--** | **--** | **3994.73** | **4022.28** | **4003.23** |
| E | 729 (315/414) | -1991.85 (5) | .96, *p*= .33 | -- | -- | 3993.69 | 4016.65 | 4000.78 |
| No Moderation | 729 (315/414) | -2003.49 (4) | 24.25, *p<.001* | -- | 23.29, *p<.001* | 4014.98 | 4033.35 | 4020.65 |
| **Parental Internalizing Problems** |  |  |  |  |  |  |  |  |
| **AE** | **729 (315/414)** | **-1988.93 (6)** | **--** | **--** | **--** | **3989.87** | **4017.42** | **3998.36** |
| E | 729 (315/414) | -1989.59 (5) | 1.32, *p*= .25 | -- | -- | 3989.19 | 4012.15 | 3996.27 |
| No Moderation | 729 (315/414) | -2000.75 (4) | 23.64, *p<.001* | -- | 22.32, *p<.001* | 4009.50 | 4027.87 | 4015.17 |

*Note.* Nested models were compared using likelihood-ratio tests of nested models. If the nested model’s 2 log-likelihood differed significantly from the more complex model the nested model’s fit was judged to be significantly worse and the more complex model was retained. The best-fitting model is indicated in bold*.* \*When model fitting of the least restrictive model (i.e., the model with more parameters) was poor we did not conduct likelihood-ratio tests.

Δ ⎯ 2LL= Difference in ⎯ 2LL(twice the negative loglikelihood) between the present model and the model that is tested; AIC= Akaike’s information criterion; BIC= Bayesian information criterion; SBIC= Schwarz information criterion; CU= callous Unemotional; CP= conduct Problems; A= additive genetic effect; E= non-shared environmental effect. *p<.05\*, p<.01\*\*, p<.001\*\*\**

**Table S6.** Unstandardized path and moderator estimates for univariate GxE models of CU traits, examining the effect of un-residualized parental acceptance, family conflict, and parental externalizing and internalizing problems

|  |  |  |
| --- | --- | --- |
|  | **Path** | **Linear Moderator** |
| **Models** | A0 | E0 | A1 | E1 |
| **Parental Acceptance**  |  |  |  |  |
| AE | .78\*\*\* [.69, .85] | .29\*\* [.16, .55] | -.19\* [-.31, -.03] | .91\*\*\* [.57, 1.05] |
| A | .64\*\*\* [.53, .73] | .75\*\*\* [.67, .82] | -.05 [-.10, .01] | -- |
| E | .79\*\*\* [.72, .86] | .61\*\*\* [.34, .72] | -- | .66\*\*\* [.37, .76] |
| **No Moderation** | **.64\*\*\* [.53, .72]** | **.75\*\*\* [.68, .82]** | **--** | **--** |
| **Family Conflict** |  |  |  |  |
| AE | .65\*\*\* [.57, .74] | .93\*\*\* [.72, 1.09] | -.35\*\*\* [-.44, -.24] | 1.10\*\*\* [.85, 1.28] |
| **A** | **.64\*\*\* [.54, .72]** | **.75\*\*\* [.68, .82]** | **.06 [-.001, .12]** | **--** |
| E | .87\*\*\* [.80, .93] | .95\*\*\* [.73, 1.11] | -- | 1.12\*\*\* [.87, 1.31] |
| No Moderation | .64\*\*\* [.54, .73] | .75\*\*\* [.67, .82] | -- | -- |
| **Parental Externalizing Problems** |  |  |  |  |
| **AE** | **.65\*\*\* [.56, .74]** | **.75\*\*\* [.67, .82]** | **.04 [-.05, .14]** | **.10\*\* [.04, .17]** |
| E | .65\*\*\* [.55, .73] | .75\*\*\* [.67, .82] | -- | .11\*\*\* [.06, .18] |
| No Moderation | .65\*\*\* [.56, .74] | .75\*\*\* [.68, .82] | -- | -- |
| **Parental Internalizing Problems** |  |  |  |  |
| **AE** | **.65\*\*\* [.56, .74]** | **.75\*\*\* [.66, .82]** | **.05 [-.04, .13]** | **.10\*\* [.03, .17]** |
| E | .65\*\*\* [.55, .74] | .75\*\*\* [.66, .82] | -- | .11\*\* [.05, .18] |
| No Moderation | .65\*\*\* [.55, .73] | .75\*\*\* [.68, .82] | -- | -- |

*Note.* The best-fitting model is indicated in bold*.* CU= Callous Unemotional; CP= Conduct Problems; A= Additive genetic effect; E= Non-shared environmental effect. Confidence intervals (95%) were derived from 10,000 bootstrap draws. Given that univariate ACE models of CU traits showed no evidence of shared environmental influences this parameter was dropped.

 *p<.05\*, p<.01\*\*, p<.001\*\*\**

**Table S7.** G × E model (Purcell) fit statistics and unstandardized path/moderator estimates of CU traits controlling for CP; residualized parental externalizing and internalizing problems

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Models** | **N (MZ/DZ)** | **Log Likelihood (df)** | **Δ ⎯ 2LL** | **AIC** | **BIC** | **SBIC** |
| *Test Model: AE* |
| **Parental Externalizing Problems** |  |  |  |  |  |  |
| AE | 729 (315/414) | -2000.59 (6) | -- | 4013.18 | 4040.73 | 4021.68 |
| **No Moderation** | **729 (315/414)** | **-2002.74 (4)** | **4.3, *p*=.12** | **4013.48** | **4031.85** | **4019.15** |
| **Parental Internalizing Problems** |  |  |  |  |  |  |
| AE | 729 (315/414) | -1998.87 (6) | -- | 4009.75 | 4037.30 | 4018.24 |
| **No Moderation** | **729 (315/414)** | **-1999.95 (4)** | **2.16, *p*=.34** | **4007.89** | **4026.26** | **4013.56** |
|  |  |  |  |  |  |  |
| **Models** | **Path** | **Linear Moderator** |  |  |
|  | A0 | E0 | A1 | E1 |  |  |
| **Parental Externalizing Problems** |   |   |   |   |  |  |
| AE | -.65\*\*\* [-.73, -.55] | .75\*\*\* [.67, .82] | -.01 [-.10, .07] | .03 [-.03, .09] |  |  |
| **No Moderation** | **.65\*\*\* [.55, .73]** | **.75\*\*\* [.68, .82]** | **--** | **--** |  |  |
| **Parental Internalizing Problems** |  |  |  |  |  |  |
| AE | .65\*\*\* [.55, .74] | .75\*\*\* [.67, .82] | .01 [-.11, .10] | .03 [-.03, .12] |  |  |
| **No Moderation** | **.65\*\*\* [.55, .73]** | **.75\*\*\* [.68, .82]** | **--** | **--** |  |  |

*Note.* Nested models were compared using likelihood-ratio tests of nested models. If the nested model’s 2 log-likelihood differed significantly from the more complex model the nested model’s fit was judged to be significantly worse and the more complex model was retained. The best-fitting model is indicated in bold*.* Δ ⎯ 2LL= Difference in ⎯ 2LL(twice the negative loglikelihood) between the present model and the model that is tested; AIC= Akaike’s information criterion; BIC= Bayesian information criterion; SBIC= Schwarz information criterion; CU= callous Unemotional; CP= conduct Problems; A= additive genetic effect; E= non-shared environmental effect. *p<.05\*, p<.01\*\*, p<.001\*\*\**

**Table S8**. Univariate variance estimates of additive (a2), shared environmental (c2), and non-shared environmental (e2) contributions to un-residualized parental acceptance and family conflict [with 95% CIs]

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Parameter estimates [with 95% CI]** |  |  |  |  |
|  | A | a2 | C | c2 | E | e2 | χ2(df) | CFI | TLI | RMSEA |
| Parental Acceptance | .16 [-.22, .54] | .02 | **.55 [.35, .74]** | **.30** | **.82 [.77, .88]** | **.68** | 11.76(6) | .93 | .96 | .05 |
| Family Conflict | **.50 [.18, .81]** | **.25** | -.33 [-.67, .01] | .11 | **.80 [.74, .87]** | **.65** | 3.53(6) | 1.00 | 1.00 | .000 |

*Note.* A= additive genetic effect; C= shared environmental effect; E= non-shared environmental effect. Confidence intervals (95%) were derived from 10,000 bootstrap draws.

**Table S9.** Bivariate ACE models [with 95% CIs]; un-residualized parental acceptance, family conflict, and parental externalizing and internalizing problems

|  |  |  |
| --- | --- | --- |
|  | **Proportion with 95% CI** |  |
|  | CU Traits | Acceptance | Total (%) |
| *Additive genetic effect (a2)* |  |  |   |
| CU Traits | **.65 [.56, .73]** | -- | 43% |
| Acceptance | -- | -- |  |
| *Shared environmental effect (c2)* |  |  |  |
| CU Traits | -- | -- |  |
| Acceptance | -- | **.55 [.31, .76]** | 31% |
| *Non-shared environmental effect (e2)* |  |  |  |
| CU Traits | **.76 [.69, .83]** | -- | 57% |
| Acceptance | **-.08 [-.15, -.01]** | **.83 [.78, .87]** | 70% |
|  | CU Traits | Family Conflict | Total (%) |
| *Additive genetic effect (a2)* |  |  |  |
| CU Traits | **.65 [.56, .73]** | -- | 42% |
| Family Conflict | **.19 [.08, .31]**  | **-.56 [-.66, -.46]** | 37% |
| *Shared environmental effect (c2)* |  |  |  |
| CU Traits | -- | -- |  |
| Family Conflict | -- | -- |  |
| *Non-shared environmental effect (e2)* |  |  |  |
| CU Traits | **.76 [.68, .83]** | -- | 58% |
| Family Conflict | **-.09 [-.18, -.002]** | **.79 [.73, .85]** | 63% |
| *Note.* As we found no evidence of shared environmental influences (C) on CU traits from our univariate etiological model all C pathways on CU traits were dropped in subsequent models. Similarly, as we found no evidence of genetic influences (A) on parental acceptance or shared environmental influences (C) on family conflict all A pathways on parental acceptance and C pathways on family conflict were dropped in subsequent models. The bivariate etiological model of CU traits and parental acceptance showed acceptable model fit well (CFI = .88, TLI= .93, RMSEA = .05 [90% C.I.=.03-.08]), as did the model of CU traits and family conflict (CFI = .96, TLI= .98, RMSEA = .03 [90% C.I.=.000-.06]). Bolded estimates contain 95% confidence intervals that do not overlap with zero. Confidence intervals were derived from 10,000 bootstrap draws. CU= Callous Unemotional. CP= Conduct Problems. |

**Table S10.** Bivariate ACE models of additive genetic (a2), shared environmental (c2), and non-shared environmental influences (e2) for CU traits (controlling for conduct problems) and each parenting environment factor [with 95% CIs]

|  |  |  |
| --- | --- | --- |
|  | **Proportion with 95% CI** |  |
|  | CU Traits | Acceptance | Total (%) |
| *Additive genetic effect (a2)* |  |  |  |
| CU Traits | **.64 [.47, .81]** | -- | 41% |
| Acceptance | .01 [-.21, .23] | .000 [-.40, .40] | 0% |
| *Shared environmental effect (c2)* |  |  |  |
| CU Traits | .12 [-.20, .44] | -- | 1% |
| Acceptance | **-.51 [-.77, -.25]** | .000 [-.35, .35] | 26% |
| *Non-shared environmental effect (e2)* |  |  |  |
| CU Traits | .76 **[.68, .83]** | -- | 57% |
| Acceptance | -.05 [-.14, .04] | **.86 [.80, .92]** | 74.3% |
|  | CU Traits | Family Conflict | Total (%) |
| *Additive genetic effect (a2)* |  |  |  |
| CU Traits | **.64 [.47, .81]** | -- | 41% |
| Family Conflict | .08 [-.16, .32] | -.37 [-.75, .003] | 15% |
| *Shared environmental effect (c2)* |  |  |  |
| CU Traits | .14 [-.17, .45] | -- | 2% |
| Family Conflict | **.36 [.07, .66]** | .000 [-.23, .23] | 13% |
| *Non-shared environmental effect (e2)* |  |  |  |
| CU Traits | **.76 [.68, .83]** | -- | 51% |
| Family Conflict | -.09 [-.19, .01] | **-.85 [-.90, -.79]** | 72.1% |
| *Note.* CU= Callous Unemotional. The bivariate ACE model of CU traits and parental acceptance showed acceptable model fit well (CFI = .92, TLI= .94, RMSEA = .04 [90% C.I.=.01-.07]), as did the ACE model of CU traits and family conflict (CFI = .97, TLI= .98, RMSEA = .03 [90% C.I.=.000-.06]). Bolded estimates contain 95% confidence intervals that do not overlap with zero. Confidence intervals were derived from 10,000 bootstrap draws. |

**Table S11.** G × E model fit statistics examining full ACE decomposition on CU traits (controlling for conduct problems)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Models** | **N (MZ/DZ)** | **Log Likelihood (df)** | **Δ ⎯ 2LL (test models below)** | **AIC** | **BIC** | **SBIC** |
| *ACE* | *AE* | *CE* | *E* |
| **Parental Acceptance**  |  |  |  |  |  |  |  |  |  |
| ACE | 770 (336/434) | -1985.04 (12) | -- | -- | -- | -- | 3994.08 | 4049.84 | 4011.73 |
| AE | 770 (336/434) | -1985.18 (11) | .28, *p*= .60 | -- | -- | -- | 3992.35 | 4043.46 | 4008.53 |
| CE | 770 (336/434) | -1985.76 (11) | 1.44, *p*= .23 | -- | -- | -- | 3993.51 | 4044.62 | 4009.69 |
| **E** | **770 (336/434)** | **-1986.00 (10)** | **1.92, *p*= .38** | **1.64, *p*= .20** | **.48, *p*= .49** | **--** | **3991.99** | **4038.45** | **4006.70** |
| No Moderation | 770 (336/434) | -1991.93 (9) | 13.78, *p*<.01 | 13.5, *p*<.01 | 12.34, *p*<.01 | 11.86, *p*<.001 | 4001.87 | 4043.69 | 4015.11 |
| **Family Conflict** |  |  |  |  |  |  |  |  |  |
| ACE | 770 (336/434) | -2317.52 (12) | -- | -- | -- | -- | 4659.03 | 4714.79 | 4676.68 |
| AE | 770 (336/434) | -1993.44 (11) | *NA\** | -- | -- | -- | 4008.88 | 4059.99 | 4025.06 |
| No Moderation | 770 (336/434) | -1994.36 (9) | *NA\** | 1.84, *p*= .40 | -- | -- | 4006.73 | 4048.54 | 4019.96 |
| **Parental Psychopathology** |  |  |  |  |  |  |  |  |  |
| ACE | 729 (315/414) | -1986.72 (8) | -- | -- | -- | -- | 3989.43 | 4026.17 | 4000.76 |
| AE | 729 (315/414) | -1986.72 (7) | .000, *p*= 1.00 | -- | -- | -- | 3987.43 | 4019.57 | 3997.35 |
| CE | 729 (315/414) | -1987.62 (7) | 1.80, *p*= .18 | -- | -- | -- | 3989.23 | 4021.37 | 3999.14 |
| **E** | **729 (315/414)** | **-1987.64 (6)** | **1.84, *p*= .40** | **1.84, *p*= .17** | **.04, *p*= .83** | **--** | **3987.27** | **4014.82** | **3995.77** |
| No Moderation | 729 (315/414) | -1992.67 (5) | 11.91, *p<*.01 | 11.91, *p<*.01 | 10.11, *p<*.01 | 10.06, *p<*.01 | 4013.96 | 4036.92 | 4021.04 |

*Note.* Nested models were compared using likelihood-ratio tests of nested models. If the nested model’s 2 log-likelihood differed significantly from the more complex model the nested model’s fit was judged to be significantly worse and the more complex model was retained. The best-fitting model is indicated in bold*.* Δ ⎯ 2LL= Difference in ⎯ 2LL(twice the negative loglikelihood) between the present model and the model that is tested; \*When model fitting of the least restrictive model (i.e., the model with more parameters) was poor we did not conduct likelihood-ratio tests.

NA= Not applicable; AIC= Akaike’s information criterion; BIC= Bayesian information criterion; SBIC= Schwarz information criterion; CU= callous Unemotional; A= additive genetic effect; E= non-shared environmental effect.

**Table S12.** Unstandardized path and moderator estimates for G × E models examining full ACE decomposition on CU traits (controlling for conduct problems)

|  |  |  |
| --- | --- | --- |
|  | **Path** | **Linear Moderator** |
| **Models** | A0 | C0 | E0 | A1 | C1 | E1 |
| **Parental Acceptance**  |  |  |  |  |  |  |
| ACE | .64\*\*\* (.44-.72) | -.07 (-.38-.17) | .74\*\*\* (.65-.81) | .07 (-.04-.17) | .11 (-.03-.24) | -.08\* (-.14--.01) |
| AE | .65\*\*\* (.52-.73) | .000 (.000-.001) | .74\*\*\* (.66-.81) | .05 (-.04-.16) |  | -.09\* (-.15--.02) |
| CE | .64\*\*\* (.45-.73) | .10 (-.13-.38) | .74\*\*\* (.65-.81) |  | .12 (-.01-.26) | -.07\* (-.12--.01) |
| **E** | **.66\*\*\* (.50-.74)** | **.000 (.000-.34)** | **.74\*\*\* (.66-.81)** |  |  | **-.07\*\* (-.11--.02)** |
| No Moderation | .64\*\*\* (.52-.73) | .000 (.000-.24) | .75\*\*\* (.67-.82) |  |  |  |
| **Family Conflict** |  |  |  |  |  |  |
| ACE | .76\*\*\* (.66-.83) | .000 (.000-.000) | .71\*\*\* (.56-.81) | -.25\*\*\* (-.39--.12) | .000 (.000-.000) | 1.25\*\*\* (.91-1.45) |
| AE | .65\*\*\* (.41-.73) | .000 (.000-.40) | .75\*\*\* (.67-.82) | .04 (-.11-.15) |  | -.003 (-.10-.11) |
| **No Moderation** | **.65\*\*\* (.53-.73)** | **.000 (-.28-.000)** | **75\*\*\* (.67-.82)** |  |  |  |
| **Parental Psychopathology**  |  |  |  |  |  |  |
| ACE | .66\*\*\* (.56-.74) | .000 (.000-.000) | .74\*\*\* (.66-.82) | .06 (-.03-.15) | .000 (.000-.000) | .11\*\* (.05-.19) |
| AE | .66\*\*\* (.55-.74) | .000 (.000-.000) | .74\*\*\* (.66-.82) | .06 (-.03-.15) |  | .11\*\* (.05-.19) |
| CE | .63\*\*\* (.33-.73) | .12 (.000-.47) | .75\*\*\* (.67-.83) |  | .04 (-.02-.17) | .13\*\*\* (.06-.20) |
| **E** | **.64\*\*\* (.54-.73)** | **.000 (.000-.000)** | **.75\*\*\* (.67-.82)** |  |  | **.13\*\*\* (.07-.21)** |
| No Moderation | .65\*\*\* (.55-.73) | .000 (.000-.000) | .75\*\*\* (.68-.82) |  |  |  |

*Note.* The best-fitting model is indicated in bold*.* CU= Callous Unemotional; A= Additive genetic effect; C= Shared environmental effect; E= Non-shared environmental effect. Confidence intervals (95%) were derived from 10,000 bootstrap draws. *p<.05\*, p<.01\*\*, p<.001\*\*\**

**Table S13.** Extended G × E means model parameters for final parental acceptance and family conflict models

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Final GxE Model** | **Grand Mean** **MZ twins** | **Grand Mean** **DZ twins** | **Moderator linked means models****MZ twins** | **Moderator linked means models****DZ twins** |
| *Twin 1* | *Twin 2* | *Twin 1* | *Twin 2* |
| **Parental Acceptance**,AE moderation(*controlling for CP*) | -.07, *p*=.20 | .03, *p*=.43 | -.04, *p*=.56 | .09, *p*=.08 | .03, *p*=.51 | .06, *p*=.16 |
| **Family Conflict**, No moderation(*controlling for CP*)  | -.06, *p*=.21 | .01, *p*=.79 | .004, *p*=.93 | .09\*, *p*=.04 | .02, *p*=.67 | .08\*, *p*=.02 |
| **Parental Acceptance**, AE moderation | -.09, *p*=.05 | .04, *p*=.33 | -.11\*\*, *p*=.005 | -.05, *p*=.18 | -.05, *p*=.20 | -.03, *p*=.36 |
| **Family Conflict**, E moderation | -.09, *p*=.06 | .04, *p*=.37 | .05, *p*=.23 | .12\*\*, *p*=.004 | .07, *p*=.07 | .09\*, *p*=.02 |

*p<.05\*, p<.01\*\*, p<.001\*\*\**

**Figure S1.** Univariate variance estimates of additive (a2), shared environmental (c2), and non-shared environmental (e2) contributions to CU Traits



*Note.* *p<.05\*, p<.01\*\*, p<.001\*\*\**