# Does Difficult Temperament Moderate Genetic and Environmental Influences on Externalizing Problems?

Kimberly J. Saudino[1] and Jody Ganiban[2]
[1]Boston University [2]George Washington University

## Introduction

- The differential susceptibility hypothesis (Belsky, 1997) suggests that there are individual differences in the susceptibility to environmental influences. That is, some individuals are more affected by their environments (both negative and positive) than others.
- Difficult temperament has been proposed as a "phenotypic susceptibility" factor that may serve as potential marker of developmental plasticity in that that temperament may be an important individual characteristic that moderates environmental influences on developmental outcomes (Belsky & Pluess, 2009).
- This hypothesis suggests that children with difficult temperaments will, in general, be more affected by the environment (i.e., more susceptible to both "good" and "bad" environments) than children with easier temperaments.
- We used the twin design to test this prediction by exploring difficult temperament as a moderator of genetic and environmental influences on externalizing behavior problems in early childhood.
- The differential susceptibility hypothesis would predict that environmental contributions to externalizing behaviors should be greater for children who are rated as having more difficult temperaments.

## Methods

### Sample

- 144 monozyogotic and168 dizygotic same-sex twin pairs (*M* age=2.07 years, *SD* =.05).

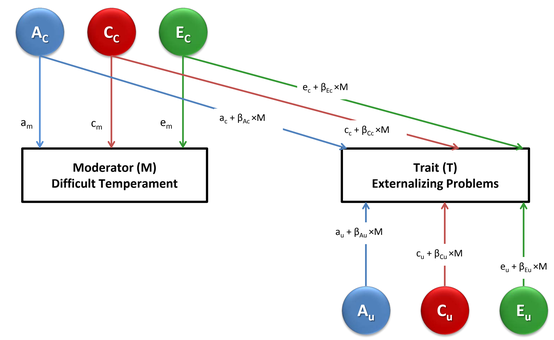
### Measures

- ***Difficult Temperament.*** Parents rated each child on the *Toddler Behavior Assessment Questionnaire* (*TBAQ*; Goldsmith, 1996). Second-order factor analysis of the TBAQ subscales, yielded a difficult temperament factor consisting of anger, activity level, sadness, soothability (reversed) and inhibitory control (reversed). This factor accounted for 36% of the variance in temperament.
- ***Externalizing Problems.*** Parents rated externalizing problems on the *Child Behavior Checklist /1½ - 5* (*CBCL*; Achenbach & Rescorla, 2000).

### Model-fitting Analyses

- A bivariate biometric moderation model (Purcell, 2002) was used to examine whether the magnitude of genetic and environmental influences on externalizing behavior problems varied as a function of difficult temperament (i.e., *genetic and environmental interaction* effects).
- This model also assesses the extent to which genetic and environmental influences are common to both difficult temperament and externalizing problems (i.e., *genetic and environmental correlations*).
- The model, depicted in Figure 1, decomposes the variances of the moderator (M) and the trait (T) and covariance between them into additive genetic (A), shared environmental (C) and nonshared environmental (E) variance components.

**Figure 1.** Bivariate Moderation Model.




- The latent variables Ac, Cc, and Ec denote genetic, shared environmental, and nonshared environmental variance components, respectively, that are common to both the M and T. These common effects represent genetic and environmental covariances between the M and T.
- The variables Au, Cu, and Eu are genetic and environmental effects on T that are independent of the moderator.
- Each path from these common and unique latent variables to T consists of a component that is unmoderated (i.e., $a_c$, $c_c$, $e_c$, $a_u$, $c_u$, or $e_u$) and a component that interacts with the moderator as represented by the regression weights (i.e., $\beta_{Ac}\times M$, $\beta_{Cc}\times M$, $\beta_{Ec}\times M$, $\beta_{Au}\times M$, $\beta_{Cu}\times M$, or $\beta_{Eu}\times M$).
- These interaction parameters allow A, C, and E on externalizing to vary dynamically as a function of the moderator (i.e., difficult temperament).

## Results

- Table 1 presents the fit statistics from the biometric moderator models. Only genetic moderation effects were significant, indicating that the influence of genetic factors on externalizing problems varied across levels of difficult temperament.

**Table 1.** Fit Statistics for Biometric Moderator Models Decomposing the Variance of Externalizing as a Function of Difficult Temperament

| Model | *-2LL* | *df* | $\chi^2$ | *Δ df* | *p* |
|---|---|---|---|---|---|
| Full | 2762.616 | 1211 | | | |
| No Moderation | 2783.023 | 1217 | 20.407 | 6 | .002 |
| **No A Moderation** | 2770.437 | 1213 | 7.821 | 2 | .02 |
| **No C Moderation** | 2765.012 | 1213 | 2.396 | 2 | .302 |
| **No E Moderation** | 2767.206 | 1213 | 4.590 | 2 | .101 |
| **No C or E Moderation*** | **2770.122** | **1215** | **7.506** | **4** | **.111** |

*Note. -2LL*= -2 log likelihood; *df* = degrees of freedom for model; $\chi^2$ = chi square for the likelihood ratio test comparing -2LL values for the Full model and reduced models dropping moderation effects ; *Δ df* = difference in degrees of freedom between Full model and reduced models. *Best fitting model.

- Estimates of genetic, shared environmental and nonshared environmental variance components for externalizing behavior problems across different levels of difficult temperament based on the best-fitting model are presented in Table 2.

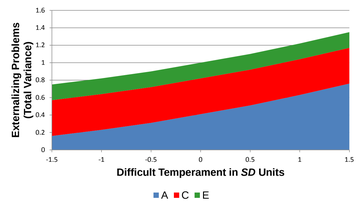
**Table 2**. Estimates of Unstandardized and Standardized Variance Components for Externalizing Problems and Genetic and Environmental Correlations Between Externalizing and Difficult Temperament Across Levels of Difficult Temperament

| | Raw Variance Components | | | | Proportion of Variance | | | Correlations | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Level of Difficult Temperament (M) in *SD* units | A | C | E | Total | A(%) | C(%) | E(%) | $r_A$ | $r_C$ | $r_E$ |
| -1.5 | .16 | .41 | .18 | .75 | .21 | .55 | .24 | .25 | .12 | .05 |
| -1.0 | .23 | .41 | .18 | .82 | .28 | .50 | .22 | .27 | .12 | .05 |
| -0.5 | .31 | .41 | .18 | .90 | .34 | .46 | .20 | .31 | .12 | .05 |
| 0 | .41 | .41 | .18 | 1.00 | .41 | .41 | .18 | .34 | .12 | .05 |
| .5 | .53 | .41 | .18 | 1.10 | .46 | .37 | .16 | .38 | .12 | .05 |
| 1.0 | .63 | .41 | .18 | 1.22 | .52 | .34 | .15 | .40 | .12 | .05 |
| 1.5 | .76 | .41 | .18 | 1.35 | .56 | .30 | .13 | .44 | .12 | .05 |
| | | | | | | | | | | |
| Unmoderated model | .51 | .30 | .18 | .99 | .52 | .30 | .18 | .39 | .07 | .05 |

*Note. SD* = Standard deviation; A = genetic variance; C = shared environmental variance; E = nonshared environmental variance; $r_A$ = genetic correlation; $r_C$ = shared environmental correlation; $r_E$ = nonshared environmental correlation.

- The raw variance components sum to the total variance. Figure 2 shows these graphically. As can be seen, the overall variance in externalizing problems increases as a function of difficult temperament. This increase in total variance is due to increases in genetic variance.

**Figure 2.** Genetic and environmental influences on individual differences in externalizing problems as a function of difficult temperament.




*Note.* E=Variance explained by nonshared environmental factors; C=variance explained by shared environmental factors; A=variance explained by additive genetic factors. *SD*=standard deviation.

- Table 2 also presents the proportion of variance attributed to each component. Although the raw shared and nonshared environmental variances for externalizing problems do not differ across levels of difficult temperament, their ***relative*** influence declines in more difficult children.
- At higher levels of difficult temperament, genetic influences on externalizing problems are relatively greater; whereas for less difficult children, estimates of heritability are lower and shared and nonshared environmental influences on externalizing problems are relatively more important.
- The genetic link between externalizing problems and difficult temperament also varies as a function of difficult temperament. As difficult temperament increases, its genetic correlation with externalizing problems also increases.

## Conclusions

- These findings provide support for the differential environmental susceptibility hypothesis.
- However, contrary to Belsky and Pluess' prediction, it is not the difficult children who were more susceptible to their environments.
- Environmental influences on externalizing problems were strongest for children who had ***easier*** temperaments.
- For children with more difficult temperaments, genetics plays a larger role in externalizing problems.
- A difficult temperament may confer a genetic risk for behavior problems.

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