Data supplement to Waller et al. Heritable temperament pathways to early callous-unemotional behaviour. Br J Psychiatry doi: 10.1192/bjp.bp.116.181503

Online Supplement DS1

Methods

Dimensions of Early Externalizing and Callous-Unemotional Behaviors. To examine callous-unemotional behaviors and control for the overlap with other early externalizing behaviors, we used a three-factor model with 17 items of the Achenbach System of Empirically Based Assessment that form separable 5-item callous-unemotional behavior (e.g., lack of guilt after misbehavior), 6-item oppositional behavior (e.g., defiant), and 6-item ADHD behavior (e.g., can't stand to wait) scales (**Fig. DS1**). This theory-based model captures dimensions of high emotional dysregulation (oppositional behavior), lack of inhibition and impulsivity (ADHD behavior), and callousness/low of empathy (callous-unemotional behavior) important for the development of early antisocial behavior (1, 2). The specific factor structure and measure of callous-unemotional behaviors has been validated in five independent samples (1, 3-5), including the current sample (6; Fig. DS1). In the EGDS, callous-unemotional behaviors at 27 months uniquely predicted teacher reports of externalizing behavior at age 7 over and above early reports of oppositional and ADHD behaviors (6). In addition, a recent meta-analysis of 10 studies demonstrated that callous-unemotional behaviors measured in early childhood (i.e., before age 5) robustly predict later externalizing outcomes, over and above other correlated early externalizing behavior measures (7).

Analytic Strategy

Addressing missing data. To account for missing data and include all 561 participants in analyses, models were estimated using maximum likelihood (ML) procedures, which are more efficient than listwise deletion and produce unbiased results with up to 50% missing at random

(or "planned missing" in our case) (8). Across measures, there was little missing data (*n*=448-561), with the exception of the observed variables, for which data were only coded for the EGDS Cohort I (*n*=361), though also within Cohort I there was a small amount of additional missing data (*n*=317-340). Observational coding was not carried out for the EGDS Cohort II (*n*=200) and can therefore be considered to be "planned missing." All models included all 561 participants with the exception of the final multi-group analyses. This final multi-group analysis only included participants in Cohort I with the observed positive parenting variable because Mplus cannot accommodate missing data for a "grouping" variable. Note that although this multi-group models was run on a subsample (*n* = 230), the model was a person-centered way to test an interaction, which had already been tested continuously using the entire sample. Both models resulted in similar results, supporting the notion that both approaches to missing data resulted in consistent conclusions.

Testing indirect effects. Indirect pathways were tested using two methods: (a) product coefficient test ("Sobel method") (9) to quantify the magnitude of the indirect effect, and (b) unbiased confidence intervals using bootstrapping methods, which do not assume normality of the distribution of indirect effects and thus represent powerful tests of indirect pathways (10).

Table DS1 Predictive validity of observed affiliative behavior measure at 18 months in relation to teacher-reported prosocial behavior at 6 years old.

	Teacher-reported prosocial behavior (age 6)	
	B (SE)	*β*
Covariates		
Child gender	1.30 (1.5)	.07
Adoption openness	.47 (.71)	.05
Perinatal complications	.02 (.21)	.01
Parent-reported child callous-unemotional behaviors (27 months)	-5.62 (3.08)	-.16†

Observed low affiliative behavior (18 months)	-1.40 (.60)	-.18*

Note. † $p < .10$, * $p < .05$. Teacher-reported prosocial behavior assessed via the egotistic-prosocial subscale of the Social Competence and Behavior Scale, an 80-item measure to assess children's adaptation to and functioning within a social and educational context (11)

Table DS2 Descriptive Statistics and bivariate correlations between study variables

	N	*M (SD)*	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
1. Child gender	561															
2. Adoption openness	541	.001 (.95)	.08†													
3. Perinatal complications	561	4.65 (3.18)	-.02	.11*												
4. Adoptive mother pos parenting (18 months)	334	.16 (.08)	-.06	.07	.02											
5. Adoptive father pos parenting (18 months)	317	.13 (.08)	-.05	.02	.05	.10†										
6. Biological mother fearlessness	513	14.78 (3.47)	.04	.09*	-.05	.07	.05									
7. Biological mother low affiliative behavior	545	4.67 (.81)	-.02	-.05	-.01	.05	-.08	.16***								
8. Adoptive mother fearlessness	448	18.05 (4.36)	.05	-.02	.08	.01	-.12†	.06	.05							
9. Adoptive mother low affiliative behavior	530	3.42 (.44)	.001	-.04	.001	-.03	-.04	.04	.02	.02						
10. Child fearlessness (18 months)	340	2.55 (.85)	.02	.06	.01	-.04	-.02	.17***	.04	-.01	-.03					
11. Child low affiliative behavior (18 months)	327	3.20 (1.19)	.05	-.02	.03	-.09†	.10†	-.07	.05	.04	-.01	.10†				
12. CU behavior (18 months)	512	1.32 (.29)	.05	.01	.04	-.17**	-.05	.01	.11*	.13**	.13**	.01	.12*			
13. ADHD behavior (27 months)	494	1.78 (.42)	.06	-.08†	-.02	-.06	-.07	.02	.06	.14**	.04	.06	-.01	.39***		
14. Oppositional behavior (27 months)	494	1.55 (.36)	-.01	-.004	-.03	-.13*	-.08	.002	.05	.07	.11*	.05	-.04	.39***	.57***	
15. CU behavior (27 months)	493	1.26 (.27)	.09*	.02	.01	-.13*	-.13*	.04	.10*	.03	.10*	.20***	.15**	.51***	.48***	.47***

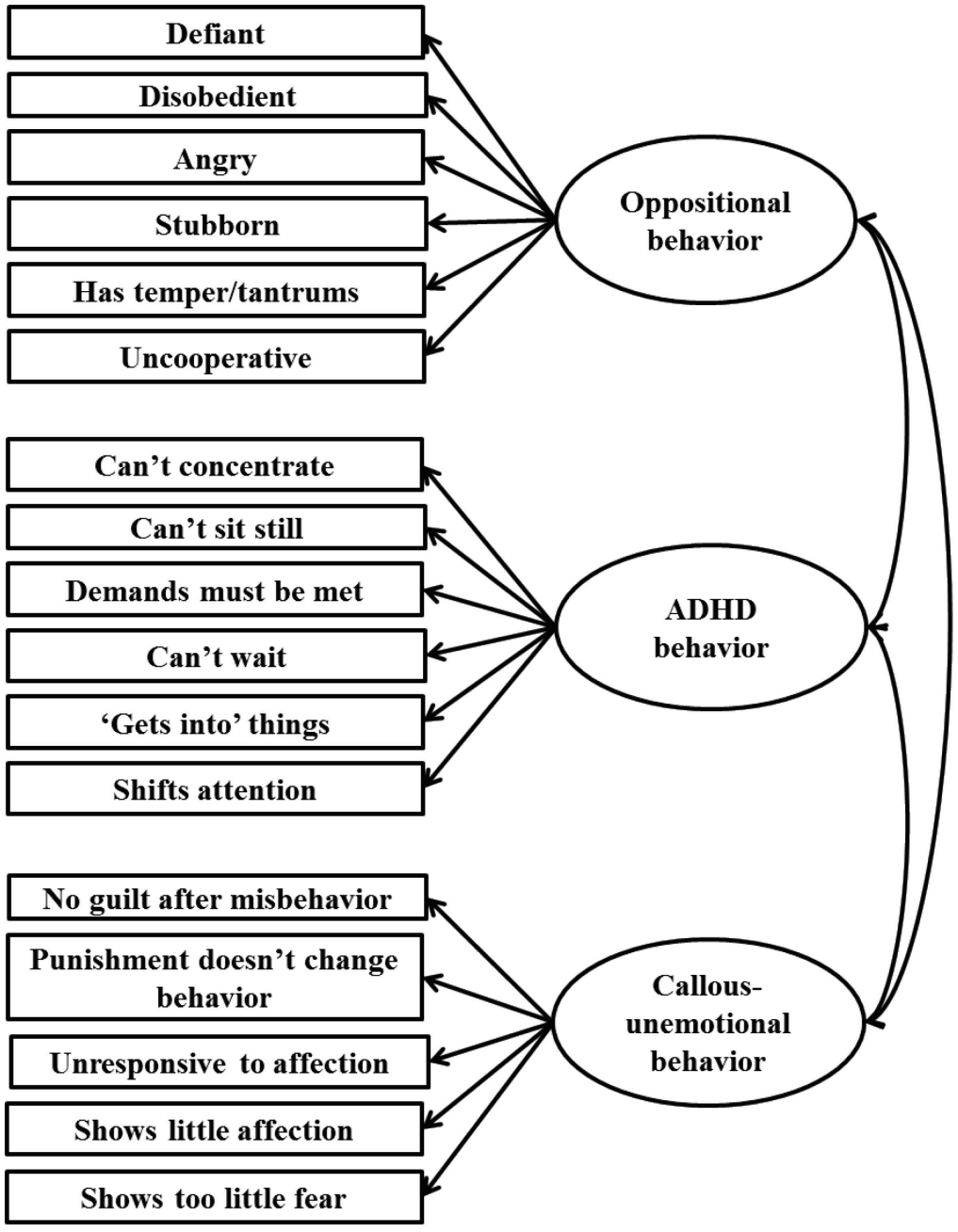
Note. † $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$. CU = callous-unemotional; ADHD = attention deficits/hyperactivity disorder

Table DS3 Observations of adopted child fearlessness and low affiliative behavior are uniquely related to later callous-unemotional behaviors in toddlerhood.

	Callous-unemotional behavior (27 months)	
	B (SE)	*β*
Covariates		
Adopted child gender	.04 (.02)	.07†
Adoption openness	.01 (.01)	.04
Perinatal complications	.002 (.003)	.02
ADHD behavior (27 months)	.20 (.03)	.31***
Oppositional behavior (27 months)	.21 (.04)	.28***
Early Child Temperament		
Observed fearlessness (18 months)	.04 (.01)	.14**
Observed low affiliative behavior (18 months)	.03 (.01)	.11*

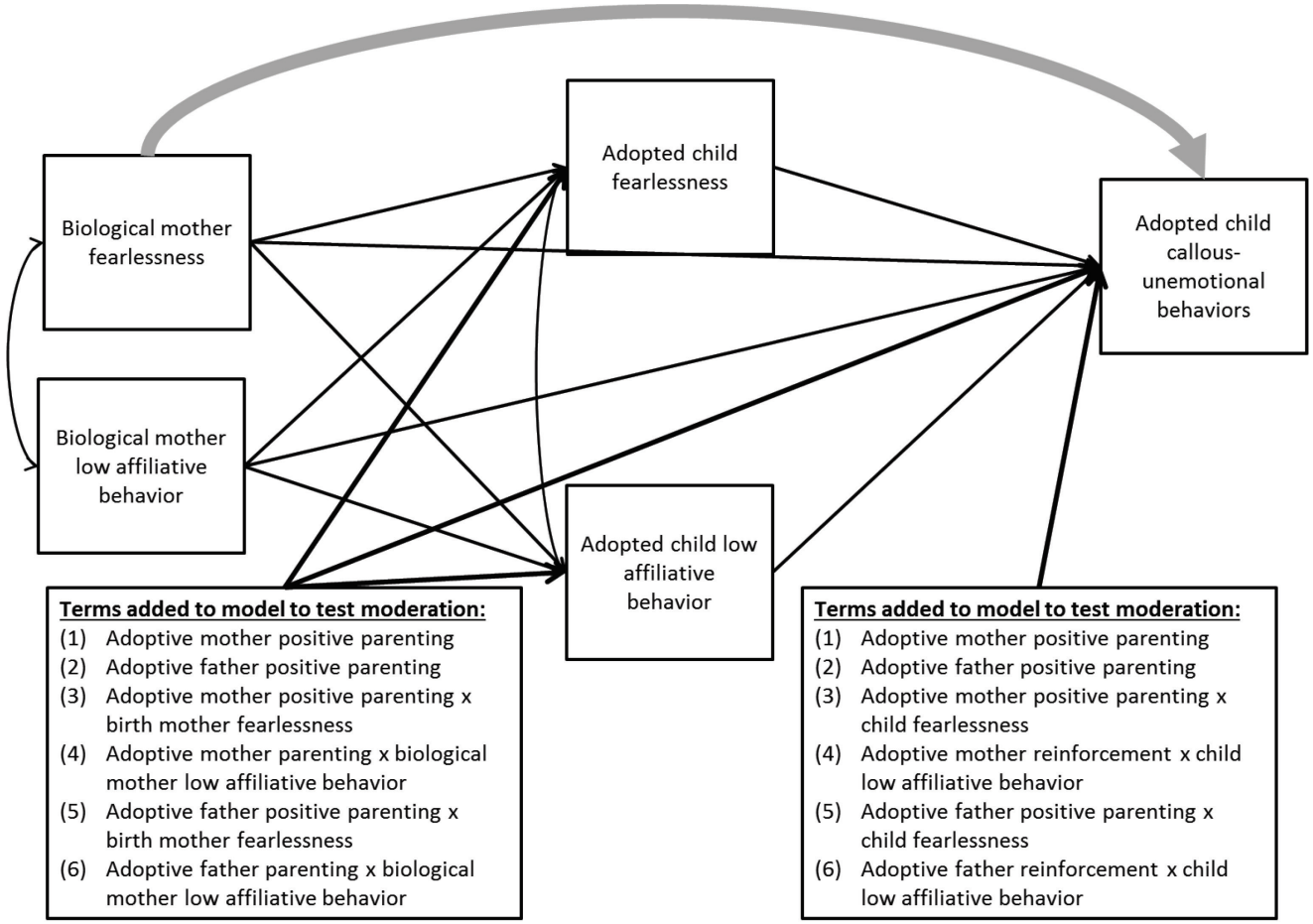
Note. † $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$. We modeled covariance between predictor variables/covariates. Using maximum likelihood estimation, the model included all 561 participants. Similar estimates obtained when a measure of earlier callous-unemotional behaviors (18 months) comprising the same five items was included as a covariate: fearlessness (18 months) → callous-unemotional behaviors (27 months), B=.05, SE=.01, β=.15, p=.001 and low affiliative behaviors (18 months) → callous-unemotional behaviors (27 months), B=.02, SE=.01, β=.08, p=.07).

Fig. DS1 Factor structure of Achenbach System of Empirically Based Assessment (ASEBA) items that load on separate Callous-Unemotional, Oppositional, and ADHD behaviors.



Note: All factor loadings, range .41-.86, $p < .001$. Correlations between factors, range = .70-73, $p < .001$. Model fit statistics: $\chi 2 = 391.97$, df = 116, $p < .001$; CFI = .94, TLI = .93, RMSEA = .069. For more details see reference (6).

Fig. DS2 Figure showing paths added to examine moderation of heritable temperament pathways by adoptive parent positive parenting



Note. To test whether adoptive parents' positive parenting practices attenuated temperament pathways, we added continuous interaction terms to our theorized model. Specifically, in a single model, we tested whether adoptive mother positive parenting and adoptive father positive parenting moderated links between fearlessness and low affiliative behavior of biological mothers and adopted children or between child fearlessness and low affiliative behavior and callous-unemotional behavior (i.e., all interaction terms were entered simultaneously to limit the risk of Type I error and limit need for multiple comparison corrections). Consistent with recommended guidelines, we mean-centered predictor and moderator variables prior to testing and probed significant interactions at 1*SD* above the mean, mean levels, and 1*SD* below the mean (Aiken & West, 1991; see **Fig. 4**).

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