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Promoting Empathy and Affiliation in Relationships (PEAR) study: protocol for a longitudinal study investigating the development of early childhood callous-unemotional traits

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ABSTRACT

Introduction Children with callous-unemotional (CU) traits are at high lifetime risk of antisocial behaviour. Low affiliation (ie, social bonding difficulties) and fearlessness (ie, low threat sensitivity) are proposed risk factors for CU traits. Parenting practices (eg, harshness and low warmth) also predict risk for CU traits. However, few studies in early childhood have identified attentional or physiological markers of low affiliation and fearlessness. Moreover, no studies have tested whether parenting practices are underpinned by low affiliation or fearlessness shared by parents, which could further shape parent–child interactions and exacerbate risk for CU traits. Addressing these questions will inform knowledge of how CU traits develop and isolate novel parent and child targets for future specialised treatments for CU traits.

Methods and analysis The Promoting Empathy and Affiliation in Relationships (PEAR) study aims to establish risk factors for CU traits in children aged 3–6 years. The PEAR study will recruit 500 parent–child dyads from two metropolitan areas of the USA. Parents and children will complete questionnaires, computer tasks and observational assessments, alongside collection of eye-tracking and physiological data, when children are aged 3–4 (time 1) and 5–6 (time 2) years. The moderating roles of child sex, race and ethnicity, family and neighbourhood disadvantage, and parental psychopathology will also be assessed. Study aims will be addressed using structural equation modelling, which will allow for flexible characterisation of low affiliation, fearlessness and parenting practices as risk factors for CU traits across multiple domains.

Ethics and dissemination Ethical approval was granted by Boston University (#6158E) and the University of Pennsylvania (#850638). Results will be disseminated through conferences and open-access publications. All study and task materials will be made freely available on lab websites and through the Open Science Framework (OSF).

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The Promoting Empathy and Affiliation in Relationships (PEAR) study is designed to assess the development of callous-unemotional (CU) traits across early childhood.

⇒ The PEAR study includes a range of assessment methods (eg, observation, computer tasks, questionnaire, eye-tracking) to assess core constructs across multiple domains (eg, behaviour, attention, physiology).

⇒ Data collection is longitudinal and allows for the investigation of biobehavioural (parent and child low affiliation and low threat sensitivity) and contextual (ie, parental harshness, low warmth and low emotion scaffolding) risk factors for CU traits, focusing on their interplay over time.

⇒ Although the origins of CU traits can be traced to infancy, the PEAR study begins recruitment at age 3, which balances a focus on early development with feasibly having young children complete computer and observational tasks.

⇒ The study is restricted to parent–child dyads residing in the metropolitan areas of Philadelphia or Boston.

INTRODUCTION

Disruptive behaviour is a core feature of oppositional defiant disorder (ODD) and conduct disorder, which are among the most common psychiatric conditions of childhood.[1 2] Disruptive behaviour disorders (DBDs) cause stress to parents and teachers and vast economic costs via health, legal and school expenditures.[3 4] Around 10%–50% of children with DBD have callous-unemotional (CU) traits (DBD+CU), defined by callousness, uncaring and remorselessness.[5 6] CU traits predict risk

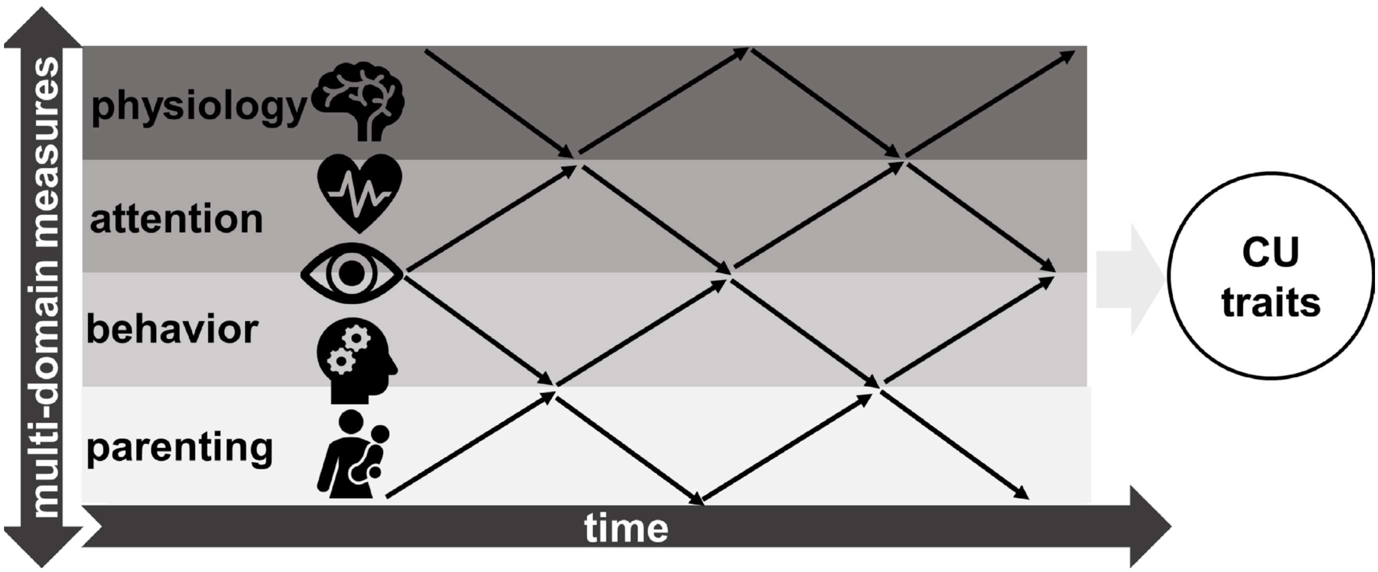

Figure 1 A dynamic systems and process-oriented developmental model depicting the development of callous-unemotional (CU) traits in the context of multiple biological, psychological and social factors interacting over time. Note: The Promoting Empathy and Affiliation in Relationships (PEAR) study is guided by longstanding developmental science and process-oriented frameworks (eg, probabilistic epigenetics; developmental psychopathology) that specify complex behavioural outcomes in the context of multiple biological, psychological and social factors interacting over time.[13 14] In the PEAR study, CU traits are proposed to develop downstream of individual differences in threat sensitivity and affiliation, which are studied dynamically across the interacting systems of physiology, attention, behaviour and parenting. Conceptual figure inspired by Gottlieb.[15]

of violence, psychopathy and arrest, even accounting for DBD severity.[7–9] DBD+CU is more heritable than DBD without CU traits (DBD-only)[10] and associated with distinct neural and behavioural correlates.[11 12] However, few longitudinal studies have investigated risk factors for CU traits in young children, which limits our ability to develop targeted treatments for DBD+CU beginning early in life. The Promoting Empathy and Affiliation in Relationships (PEAR) study aims to advance knowledge about risk factors for CU traits, with the goal of informing more effective treatments for DBD+CU.

Theoretical framework

The PEAR study draws on seminal theoretical frameworks within developmental psychopathology that leverage knowledge of typical and disrupted trajectories of child development.[13–15] Likewise, the premise for the PEAR study is that the development of CU traits can be understood in the context of multiple biological, psychological and social factors that interact over time. CU traits are similarly proposed to arise from probabilistic interactions of these factors, which gradually consolidate into a distinct, recognisable and diagnosable syndrome.[16] The PEAR study follows this logic by adopting a process-oriented framework representing CU traits as the outcome of a dynamic and multidomain system (figure 1).[15]

The PEAR study is also guided by the Sensitivity to Threat and Affiliative Reward (STAR) model, which proposes that low affiliation and fearlessness are inherited biobehavioural dimensions that increase risk for CU traits[17] (figure 2). Affiliation is characterised as the motivation for and enjoyment of social closeness.[18 19] This definition draws on studies that have investigated the biological basis of social bonding[19 20] and both the interpersonal[21 22] and neurobehavioural[23 24] features underlying adult psychopathy. Low affiliation increases risk for CU traits by disrupting children's initiation and enjoyment of social closeness with others.[17 24] Likewise, drawing on the adult psychopathy literature[25–27] and developmental models of conscience and moral learning,[28 29] fearlessness refers to reduced sensitivity to social and non-social threat cues. Fearlessness increases risk for CU traits by disrupting children's ability to learn about or adaptively respond to negative environmental input that would otherwise provoke behaviour change (eg, others' distress, punishment).[30 31]

Multidomain assessment of threat sensitivity and affiliation

Initial support for the STAR model comes from studies documenting links between CU traits and low affiliation and fearlessness using questionnaires[32 33] or observational tasks.[34–39] CU traits have also been linked to low affiliation and fearlessness using computer tasks, including difficulties recognising fearful, angry, or sad facial or bodily expressions of emotion[40–44] or responding to positive emotions and laughter.[45 46] Functional MRI studies of older children give insight into the biobehavioural mechanisms underlying CU traits, with tasks tapping into neural processes relevant to the STAR dimensions. For example, CU traits have been linked to reduced amygdala reactivity to fearful faces[47 48] (ie, presumed to reflect low threat sensitivity and/or affiliation), reduced insula activation to others' pain[49] (low threat sensitivity and/or affiliation) and reduced insula activation to laughter (low

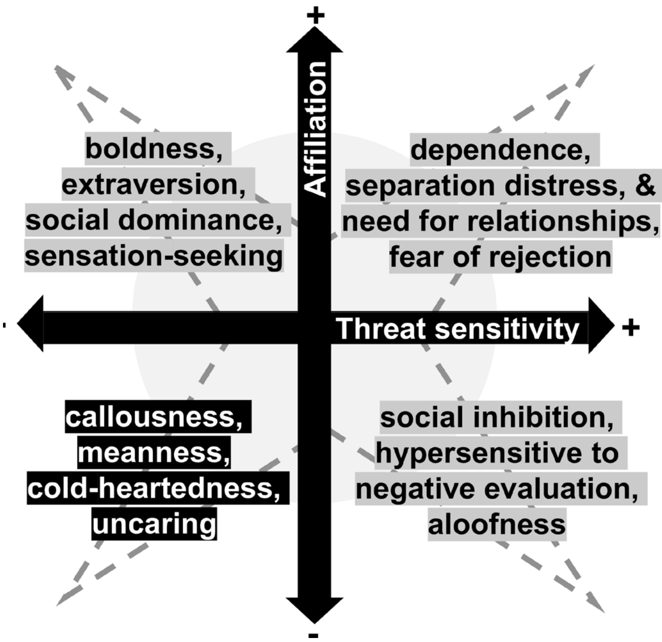

Figure 2 Sensitivity to Threat and Affiliative Reward (STAR) model, which conceptualises callous-unemotional (CU) traits as being underpinned by low threat sensitivity/fearlessness and low affiliation. Note: Figure adapted from Waller and Wagner.[17] The PEAR study focuses on assessing risk for CU traits, as represented in the lower left quadrant of the model (ie, low threat sensitivity/fearlessness and low affiliation). However, the STAR model also makes testable predictions about the other quadrants, including the combination of low threat sensitivity and high affiliation combining to produce a phenotype resembling, in its most adaptive form, boldness and extraversion, but at its most maladaptive, harmful levels of social dominance. Likewise, at high levels of fear and low affiliative reward, the model hypothesises a phenotype characterised by social inhibition, feelings of inadequacy and a hypersensitivity to negative evaluation. Finally, at high levels of fear and high levels of affiliation reward, the model hypothesises an interpersonal profile characterised by extreme and pathological dependence, separation distress and need for social relationships whose loss is fear-provoking. PEAR, Promoting Empathy and Affiliation in Relationships.

affiliation).[50] Finally, blunted physiological arousal to cues of threat or affiliation have been linked to DBD+CU in older children,[51–53] including by studies examining startle responses[54 55] (ie, low threat sensitivity) and respiratory sinus arrhythmia, which indexes connections between the frontal cortex, amygdala, nucleus solitary tract and inputs to the sinoatrial node as children respond to social stimuli[56 57] (ie, low affiliation).

This evidence provides initial support for the STAR model, but studies are needed to address several limitations. First, few studies have focused on early childhood, a period when individual differences in the defining features of CU traits first emerge (ie, low empathy and guilt)[58–60] and when interventions to mitigate risk for DBD+CU may have the greatest potential for effectiveness.[61 62] Second, while some studies suggest that CU traits arise from lower basal physiological functioning and arousal,[63] the evidence is inconsistent, potentially reflecting differences in sample age, sample type or assessment context.[64–67] Studies have also largely focused on single regulatory systems, whereas CU traits likely reflect disrupted coordination across systems (eg, sympathetic, parasympathetic, hypothalamus–pituitary–adrenal),[68 69] which has yet to be investigated within an integrated framework in early childhood. Third, unlike other Research Domain Criteria domains,[70] few computer tasks exist to assess individual differences in affiliation and fearlessness in young children (eg, adapted for touch screen), which reduces the potential for dissemination in large-scale studies or treatment settings. Fourth, prior work examining attentional biases associated with CU traits has yet to combine eye-tracking with physiological data collection, an approach that could clarify interactions between the biobehavioural mechanisms underpinning CU traits (figure 1). For example, low physiological arousal may be evident even if children attend to relevant emotional stimuli, or instead, could reflect a failure to orient to relevant cues or disengage from non-relevant cues when faced with competing stimuli.[71] Finally, no prior studies have tested specificity in the prediction of CU traits, which undermines knowledge of the unique biobehavioural markers of CU traits and our ability to establish whether sensitivity to threat or affiliation are transdimensional risk factors for other psychiatric disorders (eg, autism spectrum disorder, ODD, social anxiety) or the other quadrants of the STAR model[17] (figure 2).

Parenting influences

We also need fine-grained knowledge about how parenting influences the development of CU traits in early childhood. Parenting exerts an environmental influence on CU traits.[72 73] In particular, low parental warmth and greater parental harshness predict increases in CU traits across childhood.[73–79] Low parental warmth undermines affiliative parent–child interactions and restricts opportunities for children to experience and develop schemas for empathic and caring behaviour,[35 80] while parental harshness desensitises children to threat and models aggression as an acceptable interpersonal strategy.[81] For DBD broadly, the most effective parenting interventions involve decreasing harshness and increasing positive reinforcement.[82–84] However, meta-analytical work demonstrates that even after receiving treatments that include a parent training component, DBD+CU children exhibit greater DBD symptom severity than DBD-only children.[85]

To improve treatment outcomes, we need adapted treatments or personalised modules that address the unique socioaffiliative difficulties associated with DBD+CU, including low affiliation or fearlessness in children. However, DBD+CU children may also share such characteristics with their parents, which could shape parent–child interactions in ways that further exacerbate risk for CU traits.[62 77] For example, associations between parenting and CU traits could reflect passive gene–environment correlations (eg, parents low on warmth and children with CU traits share inherited low affiliation) or evocative gene–environment correlations (eg, fearless children evoke harshness from parents with similar traits).[86] However, no studies have examined whether parenting predicts CU traits over and above fearlessness or low affiliation measured independently in parents and/or children. In addition, no studies have examined whether parent and child fearlessness and low affiliation interact with parenting to predict CU traits. Moreover, while adaptive physiological regulation in parents has been linked to more effective parenting behaviours,[87] no studies have investigated the attentional or physiological processes related to fearlessness or affiliation in parents, which could shape their propensity to respond with harshness or warmth, thus influencing the development of CU traits in children. New additions to treatment modules could result from a multimethod investigation of affiliation and fearlessness in parents, including helping parents to better attend to or recognise emotion cues in children (eg, attentional measures) or understand their own responses to emotion cues (eg, physiological measures).

In addition, studies need to examine parental emotion scaffolding, characterised by teaching and supporting children's emotional understanding and learning, which shapes emotional resonance, regulation and expression.[88–91] Prior studies have linked CU traits to disrupted parental emotion scaffolding, including lower parental acceptance of emotion[92] and restricted expression of mental state or emotion language.[93 94] These findings are consistent with developmental studies demonstrating that improvements in children's emotion understanding predict increases in prosocial and empathic behaviour.[88–90] Alongside evidence that DBD+CU children show difficulties recognising and responding to emotions,[44 95 96] this research suggests that parental emotion scaffolding represents a critical parenting component to characterise, with promise as a potential treatment target. Thus, studies are needed that explore the main and interactive effects of parental harshness, warmth and emotion scaffolding in relation to CU traits during early childhood. These findings can inform developmental models and guide the creation of more effective treatments for DBD+CU, including teaching parents new techniques (eg, emotion scaffolding skills).

PEAR study aims

The PEAR study is a longitudinal study that will advance knowledge of developmental pathways to CU traits across early childhood (figure 3). Aim 1 of the PEAR study will investigate how low threat sensitivity and low affiliation relate to increases in CU traits across early childhood.

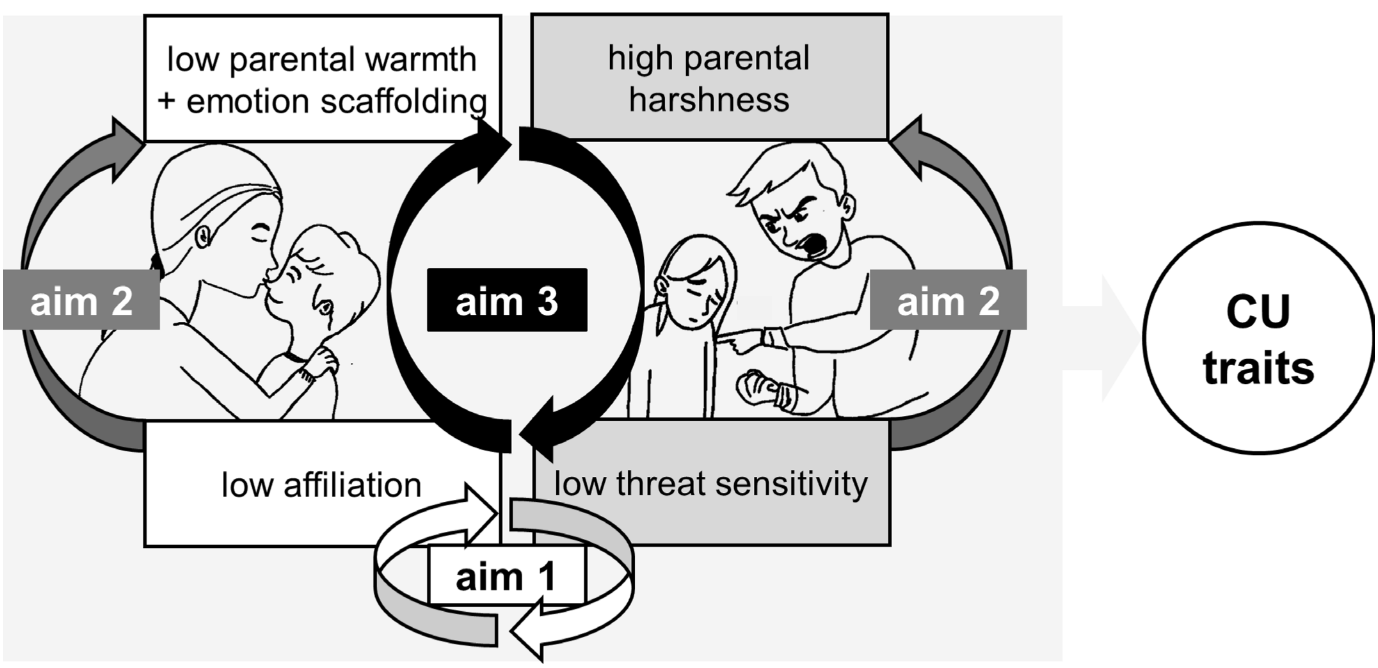

Figure 3 The Promoting Empathy and Affiliation in Relationships (PEAR) study will examine the interaction between low affiliation and low threat sensitivity in parents and children, as well as with parenting practices, to understand risk for callous-unemotional (CU) traits across early childhood. Note: Aim 1 will investigate how children's low affiliation and low threat sensitivity at time 1 are related to increases in CU traits across early childhood from time 1 to time 2. Aim 2 will investigate parents' low affiliation and low threat sensitivity and examine cross-sectional and longitudinal links with parental warmth, emotional scaffolding and harshness at time 1 and time 2, respectively. Aim 3 will test interactive associations between parent and child low affiliation and fearlessness, parenting practices and CU traits over time. All three aims prioritise multimethod assessments of behaviour, physiology and attention, as well as observed, task and report-based measures, which will allow for comprehensive, multidomain phenotyping of the core constructs (see figure 1 and table 2). We will include additional variables in the models to adjust for demographic confounds and/or to address specificity in the prediction of CU traits relative to other dimensions of psychopathology in early childhood (see table 2 and online supplemental materials).

Aim 2 will characterise parents' low affiliation and low threat sensitivity and examine links with parental warmth, emotional scaffolding and harshness. Aim 3 will test interactive associations between parent and child low affiliation and low threat sensitivity, parenting practices and CU traits over time (figure 3). Across aims, the use of multimethod assessments of behaviour, physiology and attention, as well as observational, task and report-based measures, allows for comprehensive, multidomain phenotyping of the STAR constructs, supporting the future development of precision treatments for DBD+CU.

METHODS

Study design

The PEAR study involves a longitudinal multisite design at two sites in the US with planned recruitment of 500 parent–child dyads (ie, 250 at each site). Data will be collected during lab visits at time 1 (ages 3–4) and time 2 (ages 5–6). Planned time 1 recruitment is for 550 parent–child dyads, which allows for an estimated 10% attrition rate at time 2 to increase the likelihood of obtaining a final sample of 500 dyads with data at both time points.

Study setting and procedures

Study data will be collected during 2.5–3 hours lab visits at the University of Pennsylvania or Boston University. Visits are divided into data collection blocks: (1) parent completes questionnaires, (2) child and parent complete computer and/or eye-tracking tasks and (3) parent and child complete observational tasks together/alone. Both data collection sites are equipped with identical equipment: (1) Multiple pan-tilt-zoom cameras and microphones integrated with Noldus Observer Software to facilitate coding of observable parent and child behaviour; (2) Biopac MP160 data acquisition and analysis systems with AcqKnowledge V.5 software, allowing for collection of physiological data from parents and children and synchronisation with video recordings; (3) Wireless BioNomadix modules to continuously collect parents' and children's electrocardiographic and respiratory data; (4) Wireless BioNomadix module to collect event-related electrodermal data (ie, during seated computer tasks); (5) SR Research Eyelink 1000 to capture eye-tracking data during seated computer tasks and (6) Pupil Invisible mobile eye-tracking glasses from Pupil Labs to collect mobile (ie, ambulatory) eye-tracking data during parent–child interaction tasks. All computer tasks have been built in SR Research Experiment Builder or Psychopy and are administered via high-refresh-rate touchscreen display or computer monitor. Following the visit, all participating families are compensated and provided with mental health resources. Licensed clinicians are available at both sites to provide additional support as needed.

Eligibility criteria

Eligible child participants are 3–4 years at time 1 and living with at least one biological parent who consents to participate, with English spoken <50% of the time at home. We select 50% of the sample as 'high risk' based on parental endorsement of five items to assess CU traits: 'no guilt after misbehaviour', 'punishment does not change behaviour', 'unresponsive to affection', 'shows little affection' and 'too little fear'.[97] Based on prior studies in early childhood,[97 98] Diagnostic and Statistical Manual of Mental Disorders (5th ed.; DSM–5; American Psychiatric Association, 2013) criteria for the limited prosocial emotions (CU traits) specifier,[99 100] and other large-scale studies that have recruited with an oversampling for externalising problems,[101 102] we designate children as 'high risk' if parents endorse two or more of the five items. We also recruit an estimated 2:1 ratio of male to female children to account for higher prevalence of rates of DBD among boys[103] (table 1).

Recruitment

Participants are recruited via established methods. First, our prior collaborative longitudinal work[104–106] and

Table 1 Summary of planned enrolment estimates based on risk status (high vs low risk for CU traits), child sex and site

	University of Pennsylvania		Boston University		Planned subtotals across sites by sex and age
	Low risk	High risk	Low risk	High risk	
Male (age 3 at time 1; age 5 at time 2)	42	42	41	41	166
Female (age 3 at time 1; age 5 at time 2)	20	20	21	21	82
Male (age 4 at time 1; age 6 at time 2)	42	42	42	42	168
Female (age 4 at time 1; age 6 at time 2)	21	21	21	21	84
Planned subtotal within site	125	125	125	125	Anticipated total sample with data at both time points across sites, n=500
Planned total within site	250		250		

Estimates reflect planned recruitment of 250 children at both sites (ie, combined 500 children) who will be assessed twice in the lab: time 1 (aged 3–4; years 1–2) and time 2 (aged 5–6; years 3–4). During data collection, each site will assess four families per week (≈16 per month). Note that our actual planned time one recruitment will produce a total sample of 550 (ie, add 10% to each number above at time 1), which allows for an estimated 10% attrition rate at time two and increases the likelihood of a final sample of 500 dyads with data at both time points.
CU, callous-unemotional.

literature reviews[107 108] show that social media is highly effective for recruitment. We commissioned a professionally designed and family-friendly logo for the PEAR study to support recruitment efforts. The paid functions within social media advertising provide inbuilt filtering features, which can be implemented to flexibly target under-represented groups throughout recruitment. Second, institutionally maintained databases identify individuals who have previously agreed to be contacted about research participation. These databases are generated through departmental support, collaboration across labs, outreach efforts in the community and phone calls or mailings from birth records. Finally, recruitment efforts are bolstered by the location of both labs in major metropolitan areas with vibrant paediatric research communities, including the Children's Hospital of Philadelphia and the Child and Adolescent Fear and Anxiety Treatment Center at the Center for Anxiety and Related Disorders at Boston University, which have extensive protocols for connecting families with research. When families hear about the study, they are directed to the study website and screened for inclusion using a brief survey (www.thepearstudy.com). The website includes information describing the study and compensation in plain and engaging language. Participants are compensated US$150 at time 1 and US$170 at time 2, with additional incentives to maximise participation, including babysitting for younger siblings, snacks and transportation support as needed.

Measures

Measures are gold-standard assessments of core constructs or newly developed instruments, which were validated through in-person or online pilot studies. We assess affiliation and fearlessness in parents and children across multiple domains, including behavioural, attentional and physiological responses. Parental harshness, warmth and emotion scaffolding are measured using parent report and observer ratings, with an emphasis on adapting coding schemes for observed measures to be culturally sensitive to the intersection of race and culture with parenting strategies and child behaviour.[109–111] Table 2, online supplemental materials and the PEAR study preregistration on the Open Science Framework (https://osf.io/b2rg5/)[112] summarise the assessment framework, including full description of methods and measures.

Data management

The Biostatistics and Epidemiology Data Analytics Center at Boston University School of Public Health manages study data using Research Electronic Data Capture data collection tools.[113 114] Study data also reside inside a secure, centralised and HIPAA-compliant environment. The data are stored in a restricted folder on a secure server to which only authorised PEAR study members have access. The folder is electronically encrypted, with access requiring a Virtual Private Network and two-factor authentication. All actions in the database are logged for data auditing and traceability.

Analytical plan

We will use structural equation modelling (SEM) with robust full information maximum likelihood (FIML) or weighted least square means and variance (WLSMV) estimation[115] to address study aims. We will use hierarchical factor models that parse method and construct variance to develop measurement models for core constructs, with alternative data reduction approaches (eg, multiple indicator latent factors, bifactor models) as needed to guide creation of latent variables when we have multiple measures/methods for constructs (eg, fearlessness, affiliation, parenting). Primary analyses will allow us to retain multiple-indicator latent factors, although strategies for estimating factor scores will be implemented if full measurement models appear intractable. We will probe conditional or moderated associations following recommended approaches.[116 117] We will model non-independence within dyads using multilevel SEM, which allows decomposition of between-dyad and within-dyad influences. False discovery rate corrections will be used to address multiple comparisons.[118]

Our main hypotheses centre on direct associations between parent and child fearlessness and low affiliation, parenting practices and child CU traits. Aim 1 will be tested by regressing CU traits onto latent fearlessness and affiliation factors. An interaction term between fearlessness and affiliation will be added to test whether the combination of fearlessness and affiliation explains additional variance in CU traits. Aim 1 will be tested cross-sectionally (ie, within time 1 or 2) and longitudinally by regressing CU traits at time 2 onto predictors at time 1, accounting for autoregressive effects. Aim 2 will be addressed by regressing multimethod factors of parenting (warmth, harshness and emotion scaffolding) onto parents' affiliation and fearlessness. Aim 2 will also be tested cross-sectionally and longitudinally. A series of path models will be used to address aim 3. First, to explore child–parent evocative effects, we will test associations between child fearlessness at time 1 and parental harshness at time 2 and between child affiliation at time 1 and parental warmth and emotion scaffolding at time 2 within a correlated dependent variables model, accounting for autoregressive relations. Second, to examine parent–child effects controlling for passive gene–environment correlations, we will test the main effects of parental harshness, warmth and emotion scaffolding at time 1 in the prediction of child CU traits at time 2, accounting for child and parent fearlessness and low affiliation. Third, to examine potential dyadic interactive effects, we will separately test various two-way interactions between parent and child fearlessness, low affiliation and parenting in the prediction of CU traits at time 2, accounting for autoregressive effects.

Power calculation

Statistical power was determined using Monte Carlo simulation studies, which specified multilevel simultaneous

Table 2 Overview of study measures, including construct, target, method (including multidomain assessment) and variable type in planned analyses

Construct	Target	Method	Multidomain + physiology	Multidomain + eye-tracking	Study variable
Psychopathology					
CU traits	Child	PQ: ICU,[42] CPTI,[140] SDQ[141]			Dependent variable (aims 1, 2, 3)
ODD/CD symptoms	Child	PQ: CPTI,[140] CBCL[142]			Control variables to establish specificity (aims 1, 2, 3)
ADHD symptoms	Child	PQ: CBCL,[142] SDQ[141]			
ASD traits	Child+parent	PQ: AQ[143]			
Anxiety/depression	Child+parent	PQ: child, CBCL[142]; parent, PHQ9,[144] GAD7[145]			
Psychopathic traits	Parent	PQ: SRP[146 147]			
STAR model dimensions					
Low affiliation	Child+parent	PQ: SRS2,[148] STARS[149] CT: Emotion Recognition,[150–153] Emotion Induction,[154 155] Social Preference,[156 157] CAMP OR: Child, SCALA	✓	✓	Independent variables (aim 1, 2)+moderator (aim 3)
Low threat sensitivity	Child+parent	Pq: BIQ[158] STARS[149] Ct: Visual Search,[159 160] Emotion Recognition,[150–153] Emotion Induction[154 155] Or: Child, Stranger Approach[161–164]	✓	✓	
Parenting practices					
Harshness, warmth, + emotion scaffolding	Parent	PQ: PBACE,[165] CEPAQ,[166] PS[167] OR: Storybook, Magnet and Conversation Task[101 168]	✓	✓	Independent variable (aims 1+2)+moderator (aim 3)
Additional demographic, contextual or individual-level characteristics					
Sex, age, race/ethnicity, education	Child+parent	PQ: demographic interview			Control variable to establish specificity (aims 1, 2, 3)
Parent characteristics	Parent	PQ: SUS,[169] MSSI,[170] PSI,[171] QSSI,[172] Mini-IPIP,[173] DERS-5,[174] ACES,[175] CTS2-SF[176] CT: EF touch, Theory of Mind[177] Reward Learning[178 179]	✓	✓	
Child characteristics	Child	PQ: Pediatric-ACES,[180] CSPS,[181] CCTI,[182] CARES,[183] BISQ-R[184] CT: EF Touch,[185 186] Stars in Jars,[187] Theory of Mind,[177] Picture Vocabulary Test[188]	✓	✓	
Neighbourhood+family disadvantage	Child+parent	PQ: demographic Interview, Neighbourhood Risk,[189 190] CHAOS,[191] CEFIS[192] OR: geocoding ZIP code[193]			

See online supplemental materials for detailed description of every measure, including observational tasks, computer tasks and questionnaires. Although some children will turn six by our time two assessment, we will continue to administer the CBCL 1.5–5.5 version to ensure continuity in measurement and since five items established as indexing CU traits in early childhood are not all retained in the CBCL 6–18 version.

ACES, Adverse Childhood Experiences Scale; AQ, Autistic Spectrum Quotient; ASD, Autism Spectrum Disorder; BCSP, Brief Child Sleep Questionnaire; BIQ, Behavioural Inhibition Questionnaire; CAMP, Child Affiliative Motivations and Preferences Task; CARES, Components of Affiliative Reward Experiences Scale; CBCL, Child Behaviour Checklist; CCTI, Colorado Child Temperament Inventory; CD, conduct disorder; CECPQ, Comprehensive Early Childhood Parenting Questionnaire; CEFIS, Coronavirus Disease Exposure Family Impact Scale; CHAOS, Confusion, Hubbub and Order Scale; CPTI, Child Problematic Traits Inventory; CSPS, Child Social Preference Scale; CT, computer task; CTS, Conflict Tactic Scale; CU, callous-unemotional; DERS, Difficulties in Emotion Regulation Scale; EF, Executive Functioning; GAD, Generalised Anxiety Disorder; ICU, Inventory of Callous-Unemotional Traits; Mini IPIP, Mini International Personality Item Pool; MSSI, Maternal Social Support Index; ODD, Oppositional Defiant Disorder; OPS, O'Leary Parenting Scale; OR, observer rating; PBACE, Parents' Beliefs About Children's Emotions; PHQ2, Patient Health Questionnaire; PQ, Parent-reported Questionnaire; PSI, Parental Stress Index; QSSI, Quality of Social Support; SCALA, System for Coding Affiliation in Lab Assessments; SRP, Self-Report Psychopathy Scale; SRS2, Social Responsiveness Scale; STARS, Sensitivity to Threat and Affiliative Reward Scale; SUS, Substance Use Screener.

equation frameworks that accommodate covarying outcomes. All simulation studies included a population generating model of N=500, assumed a type 1 error rate of 0.05, and involved 5000 replications.[119] Following established recommendations,[119] each simulation specified small and medium direct effects as R^2=0.02 and 0.13, respectively.[120] Each Monte Carlo study specified main effects and interactions on one outcome or multiple correlated outcomes. Results from simulations using bootstrapped standard errors to determine statistical significance at a 0.05 level (N=500) indicated power of 0.99 to detect medium-sized main effects (eg, affiliation and fearlessness to CU traits), and power of 0.93 to detect medium-sized interactive effects (ie, moderation). Results indicated a power estimate of 0.89 to detect joint contributions of parenting practices, parent and child affiliation and fearlessness, and child CU traits from time 1 to time 2. Across all models, power ≥0.80 was retained to detect small-sized to medium-sized effects (R^2≈0.02–0.10). With a sample size of 500, we retain a power of 0.80 to detect bivariate correlations |r|≥0.125, which corresponds to a small-sized to medium-sized effect.[120]

Management of bias

Various strategies are used to minimise methodological bias. First, to reduce attrition of participants, established retention strategies for longitudinal studies will be applied,[121] including ensuring flexible and advanced scheduling, recruiting research staff who are diverse in race and ethnicity, sending visit reminders, providing positive inducements (eg, babysitting), sending birthday cards and newsletters, and offering flexible solutions to support transportation (eg, Uber). Second, to reduce confounder bias, socioeconomic and demographic factors will be statistically adjusted in analyses. Contingent relationships between study variables based on these factors (ie, moderation) will also be tested in exploratory models. Third, missing data patterns will be handled using FIML or WLSMV estimation as relevant, both of which represent best practices for accommodating missing or unbalanced data.[122] Finally, procedural equivalence is maximised through identical equipment, jointly developed study procedures, and weekly meetings between staff at both sites. In addition, we ran joint training sessions across sites, study coordinators conduct weekly reviews of videos of cross-site visits, and principal investigators engage in reciprocal site visits. During analyses, multigroup modelling will establish measurement invariance for study variables across sites.[123]

Patient and public involvement

There was no patient or public involvement in the design of the PEAR study.

Ethics and dissemination

The PEAR study operates under a single Institutional Review Board that oversees data collection and modifications (Boston University, #6158E (IRB of record); University of Pennsylvania, #850638). We obtained consent from parents using electronic signatures. Minimal risk/distress to participants is anticipated, but contact numbers for counselling services are provided to families following completion of study visits. Findings will be disseminated through peer-reviewed journals (open access where feasible), conferences, professional associations and public mental health services that treat DBD. Findings will be presented in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology statement.[124] Finally, the study website and social media will also be used to disseminate results once recruitment ends.

DISCUSSION

DBDs cause harm to children's well-being, suffering to families and communities, and vast economic costs to society. CU traits designate children at high risk for developing DBD and who end treatment for DBD with greater symptom severity.[85] We need studies that begin early in life to identify modifiable risk factors associated with the development of CU traits. The PEAR study adopts a prospective longitudinal design that will advance knowledge about the development of CU traits using a multimethod approach that combines assessment of behaviour, attention and physiology.

The PEAR study has several limitations. First, while we focus on CU traits, other risk factors for DBD include disinhibition[125 126] and executive function difficulties.[127 128] We include measures to assess these constructs (table 2). However, our study focuses on threat sensitivity, affiliative processes and parenting specifically in relation to the development of CU traits. Second, we focus on parenting practices because parents represent the most proximal environmental influence on children, particularly in early childhood.[129] However, more distal environmental factors also impact risk for psychopathology, including disorganisation, instability in the home and neighbourhood disadvantage.[130–132] Brief measures of these factors are included. However, it is outside the scope of the study to assess these constructs with the same depth as the STAR dimensions. Third, our data collection targets early childhood, when individual differences in the defining features of CU traits are reliably measurable (ie, low empathy and guilt).[58–60] However, the developmental origins of these processes can be traced to infancy,[133] with some evidence for differential pathways between early fearful behavioural and physiological profiles and risk for CU traits based on environmental context.[63 134] Focusing on 3 years and 4 years balances, a need to better understand early risk factors for DBD+CU with feasibly being able to collect physiological and attentional data from young children in response to multiple social, emotional and affiliative cues. Fourth, our measurement of CU traits in the proposed study is derived only from parent report. Follow-up studies of our cohort are necessary to leverage reports from other informants (eg, educator, teacher) or methods (eg, observation of prosocial or empathic conduct in naturalistic settings) to gain insight into the pervasiveness of CU traits across contexts. Finally, the STAR model specifies that individual differences across the full spectrum of affiliation and threat sensitivity are important for conceptualising risk for different forms of psychopathology (eg, pathological dependence when threat sensitivity and affiliation are both high; figure 2). The PEAR study focuses on the quadrant of low affiliation and low threat sensitivity to characterise risk for CU traits, but future studies are needed to explore its predictive validity in relation to other personality or psychiatric disorders assessed dimensionally.[135–138]

To formulate comprehensive aetiological models of CU traits and develop targeted early interventions, we need to characterise the organisation and interaction of multiple biological and social influences early in life.[14 17 63] Longitudinal studies that pair observational, task and report-based measures with assessments of physiology and attention can establish multidomain operationalisations of fearlessness and affiliation to advance knowledge of the biobehavioural basis of CU traits in early childhood. The PEAR study addresses these needs by combining a process-oriented, multidomain approach from developmental psychopathology[13–15] with the substantive predictions of the STAR model.[17] The PEAR study aims to generate novel insights about how low affiliation, fearlessness and parenting dynamically influence the development of CU traits over time. The urgency and potential societal impact of these efforts is underscored by the staggering personal and financial costs incurred by the lifetime consequences of DBD+CU, including violence, crime and incarceration.[139]

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Supplementary Materials

The Promoting Empathy and Affiliation in Relationships (PEAR) Study: Protocol for a Longitudinal Study Investigating the Development of Early Childhood Callous-Unemotional Traits

Table of Contents

Questionnaires

The selection of questionnaires used to assess core constructs within the PEAR study was guided by existing literature, information about the measures' validity and reliability, and our own pilot data. The psychometric properties of existing questionnaires will be calculated before their use in analyses, and, in most cases, established procedures for creating composite subscales will be followed. The new measures developed for use in the PEAR study will undergo the same psychometric evaluation. Established data reduction techniques (e.g., exploratory and confirmatory factor analysis, item functioning analysis) will guide the creation of composite subscales. After eligibility has been determined, participating parents will be sent a link to complete the questionnaire battery before their lab visit through REDCap (Patridge & Bardyn, 2018).

Parent-Reported Questionnaires About Themselves

Adverse childhood experiences. We measure parents' own experiences of adversity during their childhood using the 15-item Adverse Childhood Experiences Measure (ACES-parent) (Felitti et al., 1998) (e.g., "Did you live with anyone who was a problem drinker or alcoholic or who used street drugs?"). Items are rated as either "yes" or "no". A total adverse experience score is computed by summing the number of "yes" responses.

Anxiety symptomatology. We measure anxiety symptomatology in parents using the 7-item Generalized Anxiety Disorder (GAD-7) scale (Löwe et al., 2008) (e.g., "Over the last two weeks, how often have you been bothered by not being able to stop or control worrying?"). Items are rated on a 4-point Likert scale from "Not at all" (1) to "Nearly every day" (4). An anxiety severity score is computed by summing all items.

Chaos in the home. To measure chaos and disorganization in the home, we use the 15-item Confusion, Hubbub, and Order Scale (CHAOS) (Matheny Jr et al., 1995) (e.g., "There is very little commotion in our house"). Items are rated on a 4-point Likert scale, ranging from

"Very much like our home" (1) to "Not at all like our home" (4) with items summed to index more household chaos.

COVID-19 exposure and impact on the family. We use the 30-item COVID-19 Exposure and Family Impact Scales (CEFIS) to assess the impact of COVID-19 on family members within households, extended family, and close friends (Kazak et al., 2021). Some items require a "yes/no" response (e.g., "We had a 'stay at home' order"). Other items (e.g., parenting, physical well-being) are rated on a 4-point Likert scale ranging from "[COVID-19] made it a lot better" (1) to "[COVID-19] made it a lot worse" (4), with an option to indicate if the item is not applicable. Still other items are rated on a 10-point Likert scale, from "No distress" (1) to "Extreme distress" (10) (e.g., "Overall, how much distress have you experienced related to COVID-19?"). One item is open response, and probes other positive or negative effects of COVID-19 on the family.

Depression symptomatology. We measure depression symptomatology in parents using the 9-item Patient Health Questionnaire (PHQ-9) (Kroenke et al., 2001), which assesses mood and sleep experiences (e.g., "Over the last two weeks, how often have you been bothered by having little interest or pleasure in doing things?"). Items are rated on a 4-item Likert scale from "Not at all" (1) to "Nearly every day" (4). A depression severity score is obtained by summing all items.

Emotion regulation. To measure emotion regulation difficulties in parents, we use the 36-item Difficulties in Emotion Regulation Scales (DERS-5) (Gratz & Roemer, 2004), which assesses parental emotion regulation efforts and experiences (e.g., "I experience my emotions as overwhelming and out of control"). Items are rated on a 5-point Likert scale from "Almost never (0-10%)" to "Almost always (91-100%)". In addition to a total summed emotion regulation score, there are 6 subscales: Awareness, Clarity, Goals, Impulse, Nonacceptance, and Strategies.

Harsh and ineffective parenting practices. To measure harsh or ineffective parenting practices, we use the 30-item Parenting Scale (PS) (Arnold et al., 1993), which assesses ineffective parenting behaviors. Items contain a stem followed by a response option rated on a 7-point Likert scale with 3 subscales: Laxness (e.g., “I threaten things that: ‘I’m sure I can carry out’ (1) to ‘I know I won’t actually do’ (7)”), Over-Reactivity (e.g., “When I’m upset or under stress: I am picky and on my child’s back” (1) to “I am not more picky than usual” (7)”), Verbosity (e.g., “Before I do something about a problem: ‘I give my child several reminders and warnings’ (1) to ‘I use only one reminder and warning’ (7)). Items within subscales are summed to index harsher or more ineffective parenting.

Instrumental support. To assess parental perceptions of material and tangible support in the home (i.e., instrumental help), we use the 9-item Maternal Social Support Index (MSSI) (Pascoe et al., 1988), which assesses the division of responsibility within the household (e.g., grocery shopping, paying bills). Items are rated as either “I take sole responsibility” (0) or “Someone else does this task or helps me complete the task” (1). Items are summed to create a scale with higher scores indicating more instrumental help with household tasks.

Neighborhood impoverishment. To measure neighborhood impoverishment, we use a validated 17-item scale that assesses difficulties parents perceive in their community and neighborhood (e.g., unemployment, organized crime) (Shaw et al., 2004; Shaw et al., 1998). Items are rated on a 3-point Likert scale, ranging from “Not a problem” (1) to “A big problem” (3), then summed to index more neighborhood impoverishment.

Parenting stress. We measure parenting stress using the 37-item Parental Stress Index (Abidin, 1995), which includes items such as “I often have the feeling that I cannot handle things very well” and “My child seems to cry or fuss more often than most children”. Items are rated on a 5-point Likert scale ranging from “Strongly disagree” (1) to “Strongly agree” (5), except for one write-in response. In addition to a total stress sum score, 4 subscales include Defensive Responding, Parental Distress, Parent-Child Dysfunctional Interaction, and Child Difficulty (Haskett et al., 2006).

Parental beliefs about children's emotions. To assess emotion scaffolding and parental understanding of children's emotion, we use the 33-item Parents' Beliefs about Children's Emotions (PBACE) scale (Halberstadt et al., 2013), which assesses parental conceptualizations of children's emotional experiences and states (e.g., "When children are sad, they need to find their own ways to move on"). Items are rated on a 6-point Likert scale from "Strongly disagree" (1) to "Strongly agree" (6) and summed.

Personality. To measure parental personality traits, we use the 20-item Mini International Personality Item Pool (Mini-IPIP) (Donnellan et al., 2006), which provides scores for Extraversion (e.g., "life of the party"), Agreeableness (e.g., "sympathize with others' feelings"), Conscientiousness (e.g., "get chores done right away"), Neuroticism (e.g., "have frequent mood swings"), and Intellect/Imagination (e.g., "have a vivid imagination"). Items are rated on a 5-point Likert scale from "Very inaccurate" (1) to "Very accurate" (5) and summed within subscales.

Positive parenting. To measure positive parenting, we use the 16-item Comprehensive Early Childhood Parenting (CEPAQ) (Verhoeven et al., 2017), which assesses aspects of positive parenting as reported by the parent. Subscales include Sensitivity (e.g., "I notice when my child is sad or doesn't feel good"), Responsiveness (e.g., "When my child is having a hard time, I am able to help him/her"), Affection (e.g., "I hug, kiss, or hold my child for no particular reason"), and Activities (e.g., "I tell my child stories or read books to them"). Items are rated on a 6-point Likert scale from "Never" (1) to "Always" (6) and summed within subscales.

Psychopathic traits. To assess psychopathic traits in parents, we use the Self-Report Psychopathy (SRP-SF) scale (Gordts et al., 2017; Neumann & Pardini, 2014), which is a 29-item measure that assesses psychopathic personality traits and harmful behaviors, including Interpersonal (e.g., "I have pretended to be someone else in order to get something"), Affective (e.g., "Most people are wimps"), Lifestyle (e.g., "I'm a rebellious person"), and Antisocial subscales (e.g., "I have threatened people into giving me money, clothes, or makeup"). Items are rated on a 5-point Likert scale, from “Disagree Strongly” (1) to “Agree Strongly” (5). In addition to a total sum score, subscale scores are obtained.

Quality of social support. We measure parental perceptions of the quality of their current social support using the Quality of Social Support (QSS) scale (Crnic & Booth, 1991), which is a 16-item including items such as “How satisfied are you with the number of times you talk on the phone with your friends during a typical week?”. Items are rated on a 4-point Likert scale from “Very dissatisfied (I wish things were very different)” (1) to “Very satisfied (I’m really pleased)” (4), with the option to indicate if an item is not applicable. Items are summed to create a total satisfaction score.

Relationship conflict. To measure relationship conflict in the home, we use parent report on the Conflict Tactics Scales Short Form (CTS-2 SF) (Straus & Douglas, 2004), a 20-item measure completed by parents to assess the frequency of different types of conflict in partner/spousal relationships (e.g., “I explained or suggested a compromise for a disagreement with my partner”, “My partner insulted or swore or shouted or yelled at me”). Items are rated on a 6-point Likert scale from “Once in the past year” (1) to “More than 20 times in the past year” (6). In addition to a total conflict score, there are three subscales: Physical Assault, Injury, and Sexual Coercion.

Sensitivity to threat and affiliation. To measure parental sensitivity to threat and affiliation, we use the 28-item self-reported version of the Sensitivity to Threat and Affiliative Reward Scale (STARS) (Perlstein et al., 2022), which assesses sensitivity to social threat (“It would bother me if someone else around me was crying”), non-social threat (“I worry about dangerous things or accidents happening”), physical affiliation (“I like to hug or kiss people to say hello or goodbye”), and non-physical affiliation (“I like to talk about my feelings with people”). The Threat Sensitivity subscale is computed by summing the 13 threat-related items and the Affiliative Reward subscale by summing the 15 affiliation items.

Substance misuse. To measure parental substance misuse, we use the 7-item Substance Use Screener (SUS) (Sullivan et al., 2020), which assesses parental alcohol and drug habits. Some items are rated on 6-point Likert scales (e.g., "During the last 30 days, how often did you have any type of alcoholic beverage?" with response options ranging from "Not at all" to "Every day"), some require yes/no responses (e.g., "Have you ever smoked a cigarette?"), and some require that participant write in their answers (e.g., "About how old were you when you had your first cigarette?).

Parent-Reported Questionnaires About Their Child

Adverse childhood experiences. We assess children's adverse experiences using parent report on the 17-item Pediatric Adverse Childhood Experiences and Related Life-Events Screener (PEARLS) (Ye et al., 2023). Items are rated as either "yes" or "no" (e.g., "Has your child ever lived with a parent/caregiver who went to jail/prison?") and the total number of endorsements is calculated.

Affiliative reward. To measure children's affiliative reward, we use the newly-developed 28-item Components of Affiliative Reward Experiences Scale (CARES) (Paz et al., 2023), which assesses different aspects of affiliation toward peers, family and strangers. Items are rated on a 4-point scale from "Never" (0) to "Always" (3) and summed. There are 4 subscales: Wanting to Affiliate (e.g., "Wants to be liked by other children"), Enjoyment from Experiences of Affiliation (e.g., "Likes to be part of family activities"), Understanding of Affiliative Relationships (e.g., "Understands and explains which children are his/her friends"), and Affiliative Enactment Behavior (e.g., "Plays in groups with (not just beside) other children").

Autism traits. We assess autistic traits in children using parent report on the 50-item Autism Quotient (AQ-Child) (Ashwood et al., 2016) (e.g., "[My child] prefers to do things the same way over and over again", "[My child] often notices small sounds when others do not").

Items are rated on a 4-point Likert scale from “Definitely agree” (1) to “Definitely disagree” (4). A total sum score is obtained, with higher scores indicating more autistic traits.

Behavior problems. We measure child behavior problems and prosocial behavior using parent report on the 33-item Strengths and Difficulties Questionnaire (SDQ) (Goodman et al., 2000), which assesses areas of strength and difficulty for children (e.g., “[My child] often loses temper”). Items 1-25 are rated on a 3-point Likert scale from “Not true” (1) to “Certainly true” (3). The remaining items probe the extent of the difficulty experienced by the child and family, and in what domains (e.g., friendships, classroom learning). In addition to a total difficulties summed score, we compute subscale scores summing items within the Conduct Problems, Emotional Problems, Hyperactivity, Peer Problems, Prosociality, and Impact scales (i.e., how impactful difficulties have been for child and family).

Behavioral inhibition. We measure child behavioral inhibition using the 30-item Behavioral Inhibition Questionnaire (BIQ) (Kim et al., 2011). Parents rate how often a statement (e.g., “[My child] approached new situations or activities very hesitantly”) describes their own child on a 7-point Likert scale from “Hardly ever” (1) to “Almost always” (7). In addition to a total behavioral inhibition sum score, subscale scores can be obtained for Unfamiliar Peer Engagement, Unfamiliar Adult Engagement, Performance Situations, Separation/Preschool, Unfamiliar Situations, and Physical Challenge.

Callous-unemotional traits. Child callous-unemotional (CU) traits are assessed using parent report on the 24-item Inventory of Callous-Unemotional Traits (ICU) (Cardinale & Marsh, 2020; Kimonis et al., 2016; Kimonis et al., 2008), which provides subscale scores for Callousness (e.g., “unconcerned about feelings of others”), Uncaring (e.g., “always tries best”), and Unemotionality (e.g., “hides feelings”). Items are rated on a 4-point scale from “Not at all true” (0) to “Definitely true” (3) and summed.

Child temperament. We measure child temperament using 30-item Colorado Child Temperament Inventory (CCTI) (Plomin & Rowe, 1977). Items are rated on a 5-point Likert scale from “Strongly disagree” (1) to “Strongly agree” (5). There are 6 sum-score subscales: Sociability (e.g., “[My child] makes friends”), Activity (e.g., “[My child is] energetic”), Emotionality (e.g., “[My child is] upset easily”), Attention Span-Persistence (e.g., “[My child] plays with a single toy”), Reaction to Food (e.g., “[My child] rarely took new food without fussing”), and Soothability (e.g., “[My child is] easily distracted when crying”)

Problematic traits. We measure problematic personality traits and temperament in children using the 28-item Child Problematic Traits Inventory (CPTI) (Colins et al., 2014), which assesses grandiose deceitfulness, callous unemotionality, and need for stimulation. Items are rated on a 40-point Likert scale from “Does not apply at all” (1) to “Applies very well” (4). In addition to a total sum score for problematic traits, subscales may be calculated for Grandiose Deceitfulness (e.g., “[My child] lies often to avoid problems”), Callous Unemotionality (e.g., “[My child] seldom expresses sympathy for others”), and Need for Stimulation (e.g., “[My child] likes change and that things happen all the time”).

Psychopathology. To measure general symptoms of psychopathology in children, we use parent reports on the Child Behavior Checklist (Achenbach & Rescorla, 2000), a widely-used 100-item measure that assesses behavioral difficulties in preschool-aged children. Items (e.g., “[My child] acts too young for age”) are rated on a 3-point Likert scale from “Not true (as far as you know)” (0) to “Very true or often true” (3). We compute total sum scores for Internalizing and Externalizing psychopathology, as well as DSM-5 oriented subscales assessing symptoms of Anxiety, Oppositional Defiant, and Attention-Deficit Hyperactivity Disorders.

Sensitivity to threat and affiliative reward. Child sensitivity to threat and affiliation are measured using the parent-reported version of the Sensitivity to Threat and Affiliative Reward Scale (STARS) (Perlstein et al., 2022), described above.

Sleep. We assess child sleep using parent report on the 20-item Brief Sleep Questionnaire (BISQ-R) (Mindell et al., 2019), which assesses child sleep patterns (e.g., “In a typical week, how often does your child usually have the exact same bedtime routine?") and caregiver impressions of sleep behavior (e.g., "Typically, how difficult is bedtime?").

Social preferences. We measure children's social preferences using the 11-item Child Social Preference Scale (CSPS) (Coplan et al., 2004), which assesses children's social tendencies. Items are rated on a 5-point Likert scale from "Not a lot" (1) to "A lot" (5). In addition to a total social preference sum score, subscale scores for Shyness (e.g., "My child seems to want to play with other children, but is sometimes nervous to") and Social Disinterest (e.g., "My child often seems content to play alone") can be obtained.

Social Responsiveness. We measure child social responsiveness using the 65-item Social Responsiveness Scale (SRS-2) (Uljarević et al., 2019), which assesses social ability and responsiveness in children aged 2 years, 5 months to 18 years. Items are rated on a 4-point Likert scale from "Not true" (1) to "Almost always true" (4). A total sum score measuring social deficits is obtained, in addition to five subscales that include Social Awareness, Social Cognition, Social Communication, Social Motivation, and Restricted Interests.

Physiology and Eye-tracking

Simultaneous Assessment of Attention and Physiology

A key point of innovation of the PEAR Study is the multi-method approach to assessing risk factors for CU traits. Specifically, we assess multiple indicators of neurophysiological and attentional functioning across contexts. Participating parents and children wear mobile devices to allow for the continuous and time-synchronized collection of cardiac physiology and respiration data, and both stationary and mobile eye-tracking devices will be used to assess various aspects of attention across computer-based and interaction tasks. In addition to collecting these data while participants are engaged in various tasks, we collect tonic or resting data while they watch a 3-minute nature clip. The child watches the video on a touchscreen computer while the parent watches the video concurrently on a desktop monitor in a separate room. The maintenance of homeostasis is itself a dynamic process that provides insight into an individual's capacity to adaptively navigate a changing environment (Cacioppo & Berntson, 2011), and baseline cardiac functioning is an established biomarker of emotion dysregulation and risk for psychopathology (Beauchaine, 2015). We use resting physiology data to calculate task-related physiological responding. Moreover, the synchronization of the physiological data and video recordings will allow us to model dynamic change in these systems across tasks (e.g., vagal flexibility) (Burt & Obradović, 2013; Wagner et al., 2023).

Autonomic Nervous System Functioning

Participants' electrocardiogram (ECG), electrodermal activity (EDA), cardiac output (NICO), and respiratory effort (RSP) will be collected throughout the visit using Biopac MP160 data acquisition and analysis systems with AcqKnowledge 5 software. Respiration will be collected using an elastic respiration band worn around the participant's chest. We will use two Wireless BioNomadix modules attached to the respiration belt to transmit ECG, NICO, and RSP. One BioNomadix transmitter is worn on the wrist to transmit EDA. We will apply 3 peel-and-stick hypoallergenic electrodes (EL512 1" round foam electrodes) to participants' chests to obtain ECG and 8 electrodes to obtain NICO (4 electrodes on the neck, with two on each side; 4 on the ribs, with two on each side). EDA signal will be obtained with 2 electrodes worn on the palm of the hand. Shielded lead wires will be used to connect electrodes to the transmitters. ECG will be used to derive respiratory sinus arrhythmia (RSA), while NICO data will be used to derive PEP (pre-ejection period), and EDA will be analyzed for skin conductance responses (SCRs). We will use Observer XT (Noldus Information Systems) to synchronize psychophysiology data to the millisecond with video recordings collected in Noldus MediaRecorder6.

Once collected, physiology data will be processed in AcqKnowledge 5 by down-sampling the data, applying a high- or low-pass filter to minimize "noise", and creating timestamps marking the beginning and end of each experimental task. EDA and NICO artifacts will be edited in AcqKnowledge, while artifacts in ECG data will be edited with CardioEdit software. AcqKnowledge will be used to derive PEP from NICO data and SCRs from EDA. Task-specific RSA estimates will be calculated using CardioBatch software. RSA reactivity during tasks will be computed as an overall change from baseline (collected during 5 mins at the start of the visit when children sit and draw) and/or as a dynamic change across task epochs.

Stationary Eye-Tracking

Participants' eye movements will be measured using a desktop-mounted Eyelink 1000 Plus (SR Research Ltd., Ontario, Canada) during computer tasks designed to assess attentional processes relevant to threat and affiliation. Participants will place their heads on an adjustable tower mount chin rest and wear a bullseye calibration target sticker on their forehead to adjust for head movements. Stimuli will be presented on a desktop monitor approximately 60 cm away from the participant. All stimuli were created using SR Research Experiment Builder (SR Research Ltd., version 2.4.77). Stimuli are presented on a high refresh rate (i.e., 144 Hz) display, allowing for gaze-contingent research. Eye-tracking data are captured using the Eyelink 1000 Plus, which samples binocularly at up to 2000 Hz. Eyelink allows for accurate binocular/monocular, unstabilized tracking with an average accuracy of <0.5 degrees. For adult participants, a 9-point target display is used for calibration and validation of eye position, while a 5-point animated target display (i.e., an image of a spinning beach ball, lion, and star) is used for child calibration and validation. Data Viewer (SR Research Ltd., version 3.2) will be used to create static and dynamic interest areas and output variables such as dwell time, saccadic reaction time, and interest area reports.

Mobile Eye-Tracking

Mobile eye-tracking enables eyeglasses-based video recorders to register the eye gaze of participants within their visual environment. During tasks for which we collect mobile eye-tracking data, participants will wear Pupil Invisible eye-tracking glasses (Pupil-Labs GmbH, Berlin, Germany). The glasses are equipped with two cameras (sampling frequency of 200Hz@ 192 × 192px) facing inward to capture the participants' eye and record pupil movement, and an outward-facing camera (60Hz@ 1280 × 720px) attached to the earpiece to record a video of the participant's "visual world". An adjustable elastic strap is attached to the back of the glasses to ensure that the glasses fit the participants' heads. A USB cable connects the glasses to a OnePlus 8T Android smartphone that runs the Pupil Invisible Companion app. The app creates a recording overlaying the participant's eye fixations with the "point-of-view" video of the participant's visual surroundings.

Phones will be placed in mesh fanny packs worn by the participants to allow ventilation during recording sessions. Participants will complete a calibration procedure at the beginning of the recording session by looking at five points on a paper bullseye calibration target, which is mounted to the wall approximately two feet away from the participant at their eye level. Participants repeat the calibration procedure once to perform validation. In addition, two drift checks will be performed, one at the end of each set of parent-child interaction activities.

Eye-tracking recordings will be uploaded to the Pupil Player app, where the eye-tracking footage, depicted by a set of circles and cross-hair lines, will be merged with the participant's visual world video. Manual gaze correction will be performed by adjusting the x and y coordinates of the eye gaze to align with the fixation points on the calibration target. The corrected recordings will be exported and coded for the duration of fixation on the toys (e.g., magnet tiles, picture book), objective within the testing room (e.g., fridge, rug, wall decal), and looks to the parent or child, with mutual eye-contact between parent-child dyads during interaction tasks as a variable of interest.

Behavioral Tasks

Behavioral, task-based data will be collected using a touchscreen or a computer via keyboard and mouse input. As with our questionnaires, task selection was guided by existing literature, information about the measures' validity and reliability, and our own pilot data. Tasks were built using Psychopy (Peirce, 2007) and Experiment Builder (SR Research Ltd., version 2.4.77). Other tasks, such as EF Touch and the NIH Toolbox Picture Vocabulary Test, are deployed using existing software (e.g., NIH Toolbox).

Parent Computer Tasks

Behavioral and visual attention bias to threat. To assess behavioral and visual attention to social and nonsocial threat cues in parents, we use an adapted version of a visual search paradigm previously validated in adults (LoBue, 2009; LoBue & DeLoache, 2008). During each trial, participants see a 3 by 3 grid of nine images and are instructed to touch or click on the image that is "different from the others as quickly as possible". During social trials, participants identify the angry, fearful, or happy face from among 8 neutral faces. During non-social trials, participants select the snake or frog from among 8 images of flowers. Accuracy and reaction time are recorded. Following one untimed scaffolding trial and two timed practice trials, adults complete 48 trials on the eye-tracking computer using a desktop monitor and mouse. Half the social trials are with child faces and half with adult faces. The outcome of interest is response time to threatening (angry and fearful faces; snakes) and non-threatening (happy faces and frogs) stimuli.

Emotion induction. To evaluate parental sensitivity to emotion, we use an emotion induction task, the Emotion Video Experience Ratings (EVER) task, which is a passive-viewing and rating task combined with the collection of physiological (e.g., heart rate, skin conductance) data that can give novel insight into the impact of videos that are expected to elicit different emotional responses in adults. During each trial, participants view a 1-minute neutral baseline clip from a nature documentary overlaid with neutral music, followed by a 2-minute movie clip intended to induce a discrete emotion. The subjective emotional impact of the chosen clips was validated in a separate sample and, in some cases, in prior work (Dadds et al., 2016; Gross & Levenson, 1995; Schaefer et al., 2010). Target emotions are 2-minute clips depicting fear (*The Babadook*), happiness (*Mamma Mia!*), sadness (*The Champ*), and anger (*My Bodyguard*). Following each trial, participants rate how pleasant (i.e., valence) and stimulating (i.e., arousal) they found the clip on 9-point Likert scales guided by the Self-Assessment Manikin (Bradley & Lang, 1994). They also rate the greatest degree they experienced each of six discrete emotions (anger, fear, disgust, happiness/amusement, sadness, surprise) during the clip on a 9-point Likert scale. Physiological and eye-tracking (e.g., saccades, fixations) data will be collected.

Emotion recognition. To assess emotion recognition in parents, we use an adaptation of a task that assesses accuracy in recognizing and labeling facial expressions that convey specific emotions (Brislin & Patrick, 2019). Participants view a photo of an adult expressing a discrete emotion (750 ms) and use a computer mouse to select an emotion label (3 sec). Stimuli consist of images of adults expressing one of six discrete emotions (anger, disgust, fear, happiness, sadness, or surprise) at one of three intensity levels (33% emotional, 66% emotional, 100% emotional) based on morphing with a photo of the same actor displaying a calm expression. Images are from the full-color RADIATE face set (Conley et al., 2018) and comprise one male and one female actor from each of the following racial groups: East Asian, Black, Hispanic, and White. Participants are presented with one image from each actor, emotion, and emotional intensity combination (e.g., one trial of the East Asian female displaying 33% anger) in a randomized order. The primary outcome of interest is accuracy of emotion identification. Eye-tracking data will also be collected to assess eye activity (e.g., saccades, fixations).

*Reward learning***.** To assess reward learning in parents, we use an adapted version of a reward learning task presented on the touchscreen (Wimmer et al., 2018; Wimmer & Poldrack, 2022). During each trial, parents are presented with an image of one of four different colored jars, along with response options of an up and a down arrow. Two of the jars are more rewarding, and two of the jars are more punishing on average. When the up arrow is selected on reward trials, participants have an 80% chance of winning an average of 25 points and a 20% chance of losing an average of 5 points. Conversely, when participants select the up arrow on punishment trials, there is an 80% probability of losing an average of 25 points and a 20% probability of a neutral outcome (0 points on average). When the down arrow is selected on a reward trial, participants have an 80% chance of losing 5 points on average, and a 20% chance of gaining an average of 25 points. When participants select the down arrow on a punishment trial, there is an 80% probability of a neutral outcome (0 points on average) and 20% probability of losing an average of 25 points. Exact point amounts are jittered 5 points around the mean using a flat/universal distribution. As part of the task, there are three phases: learning, rating, and choice. The learning phase consists of 12 practice trials and 40 experimental trials. Participants learn that for half of the stimuli (the “reward” stimuli), it is better, on average, to press the “up” key, and for the other half (the “loss” stimuli), it is better, on average, to press the “down” key. Next is the rating phase, where participants rate how rewarding each stimulus was on a sliding scale, and then the choice phase, where participants are shown two stimuli and must choose which they believe was more rewarding. The primary variable of interest is the number of trials required for participants to learn which jars are associated with reward and which with punishment.

Child Computer Tasks

Behavioral and visual attention bias to threat. Children complete the same attention bias task as adults (i.e., using emotional faces and animals); this task was previously validated in our target age group (3-5 year-olds) (LoBue, 2009; LoBue & DeLoache, 2008). In contrast to the adult version of the task, children complete 30 experimental trials on a touchscreen, and all social trials contain children's faces.

Emotion induction. To evaluate child sensitivity to emotion, we use a similar task to the EVER paradigm described above, but using developmentally appropriate videos from *The Lion King.* The subjective emotional impact of the chosen clips was validated in prior work (Dadds et al., 2016; Kimonis et al., 2023). Target emotions are in 2-minute clips depicting fear, happiness, sadness, and anger. The videos are passively viewed; there is no rating component to the child version of the task.

Emotion Recognition. Children's emotion recognition is assessed in a newly-developed touchscreen task separated into three parts. The first part of the task is the "evaluation" section, in which children see a grid of four different child faces, each showing a different emotion (happy, angry, sad, or scared). Children are asked how each face feels to get a baseline assessment of whether they can generate the correct emotion word. Next, as a "test", children see a grid of four new emotion faces and are prompted to touch the face that matches a given emotion label provided by the experimenter (e.g., "find the friend who feels happy"). The remaining two sections, "matching" and "receptive labeling," are presented in counterbalanced order. In the "matching" section (adapted from Székely et al., 2011), children are shown an emotion face (happy, angry, sad, or scared) at the top of the screen for two seconds. Then, while the top image remains on the screen, two images of a different child (of the same sex and race) are presented below—one displaying an emotion matching that of the image above, and one "contrast" emotion. Children have up to six seconds to select the new image that matches the emotion of the top image. In the "receptive labeling" section (adapted from Wu et al., 2023) children are presented with two images of the same child, one showing the target emotion, and the other showing a contrast emotion. A voiceover directs the child to select the face showing a certain emotion (happy, angry, sad, or scared). Children have 10 s to choose the correct image. Both the "matching" and "receptive labeling" sections have 24 test trials each— six of each target emotion. The response options from the "matching" section are the same images used in the "receptive labeling" section, with an additional 24 face images (one per trial) used as the target stimuli in the "matching" section. All stimuli are from the Child Affective Facial Expression set (LoBue & Thrasher, 2015) and reflect equal proportions of male and female actors; they are 50% white, 42% Black, and 8% Asian, to roughly reflect our intended participant sample.

Executive functioning. We assess child executive functioning using two touchscreen tasks from "EF Touch," a battery of seven executive functioning and two non-executive functioning tasks developed specifically for use with 3- to 6-year-old children (Willoughby et al., 2017; Willoughby et al., 2013). The first task, Bubbles, assesses general reaction time (to be used as a covariate in analyses of other behavioral data). Children see blue circles (i.e., "bubbles") appear at different locations on a screen and are instructed to press the bubbles as they appear as fast as possible. Next, the Arrows task measures inhibitory control. Two green buttons appear on the bottom half of the screen. In each trial, an arrow pointing either left or right appears at the top left or right of the screen. Children are instructed to press the green button that the arrow is pointing to as fast as possible. During congruent trials, the arrow appears above the same button it is pointing to (e.g., the arrow appears above the right-hand button and is pointing to the right). During incongruent trials, the arrow appears above the opposite button from the one it is pointing to (e.g., the arrow appears above the right-hand button but is pointing to the left). For the incongruent trials, children must suppress the dominant response of pressing the button that the arrow is above. Children have 2 seconds to respond before the screen advances to the next trial. The primary outcome of interest is accuracy and reaction time on congruent and incongruent trials.

*Reinforcement learning to reward and punishment***.** To assess children's reinforcement learning to reward and punishment, we use an adapted touchscreen version of the Stars in Jars task (Briggs-Gowan et al., 2014). During each trial, children see an illustration of one of four jars of different colors and shapes appear on the touchscreen monitor. Two jars always have stars in them, and two are always empty. Children learn that if they touch a jar with stars in it, they win points, and if they refrain from touching an empty jar, they also win points. If they touch an empty jar or do not touch a jar with stars in it, they lose points. Thus, children learn to click on the “rewarding” jars and avoid clicking on the “punishment” jars. The task begins with scaffolding, in which the child and experimenter explore if practice jars have stars inside. Then, the child completes up to 5 practice rounds before advancing to the experimental trials, of which there are 36. In both the practice and experimental trials, there is a time limit of 10 seconds.

Social motivation and preference. Children who display similar social behaviors may vary in their affiliative preferences and motivations (Kopala-Sibley & Klein, 2017). To assess children’s affiliative and instrumental motivations and preferences for engaging in social behavior, we developed a new digital storybook task, the Child Affiliative Motivations and Preferences (CAMP) task, which is presented on the touchscreen. The task presents drawings of cartoon bears that represent peer-directed social contexts across three types of play (active, associative, and collaborative). The child is told that the drawings of cartoon bears depict the child and their peers. To emphasize that the bear represents the child, children personalize the image of the bear at the beginning of the task by selecting a hat or bow for the bear to wear. In each trial, the child hears a voiceover and sees a drawing on the left side of the screen introducing the setting (e.g., “It’s time to play in the sandbox”, along with a drawing of a bear in a sandbox) and two drawings on the right side of the screen, one at the top and one at the bottom. The experimenter asks the child which of the two settings they would pick. One of the drawings represents a social setting (e.g., a bear playing with a peer in the sandbox), and the other a less social setting (e.g., a bear playing alone in the sandbox). Once the child selects a response by pressing on the drawing, the task moves on to the next trial. Each type of play is presented across 3 contexts in a random order for a total of 18 trials. Examples of active contexts include playing hopscotch and ball, examples of associative contexts include eating lunch or walking home, and examples of collaborative contexts include gardening and doing a puzzle. The child is asked, "which one would you pick?" between two options depicting (a) a group of peers vs. one peer, (b) a group of peers vs. playing alone, or (c) one peer vs. playing alone. The selections represent what the child prefers to do in a social situation devoid of social confounds, such as fear of rejection.

Theory of mind. To assess children's theory of mind, including its cognitive and affective aspects, we use an adapted touchscreen version of the CAToon Task, which was originally developed and validated in an MRI study with 3- to 9-year-olds (Borbás et al., 2021). Our adapted task consists of 24 hand-drawn stories, with 8 stories selected from each of three conditions: affective theory of mind (AT), cognitive theory of mind (CT), and a control condition of physical cause and effect (PC). During AT trials, participants infer how a character would respond to another character's expressed or inferred emotions. During CT trials, participants choose how a character would behave based on another character's intentions or beliefs. Finally, PC trials depict basic laws of physics and serve as a control to demonstrate that the participant understands cause and effect. The task begins with one scaffolding trial, followed by 2 practice trials, and 18 experimental trials. The order of the stories is randomized. In each trial, three images from a story are presented one after another on the touch screen. Each image is presented for 3 seconds. Then, three new images are presented on the screen. Participants are instructed to select the ending that "best fits the story" by touching the corresponding image on the screen. CT and PC trial endings consist of one possible, one improbable, and one impossible solution. AT trials have two possible solutions (one positive expectancy and one negative expectancy outcome) and one impossible solution. Accuracy for each condition and positive/negative expectancy for the AT condition are the primary variables of interest.

Verbal ability. We will assess children's verbal ability using the NIH Toolbox Picture Vocabulary Test, a computerized measure of receptive vocabulary developed to assess auditory comprehension of single words in participants ages three and older (Gershon et al., 2014). On each trial, children are presented with an audio recording of a word and 4 photographic images on an iPad screen. The child is asked to touch the picture that matches the word's meaning. Once the participant completes the first trial, the program selects the subsequent trial based on the accuracy of the previous response. Successive trials are selected using an updated estimate of the participant's proficiency, such that the task continues until participants' standard error of performance falls below 0.3. The child's performance on the task will be used to index verbal ability as a control variable for other tasks (e.g., receptive emotion recognition task).

Observational Tasks

Procedures

Children will complete one interaction task with a stranger to evaluate behavioral inhibition, and parents and children will engage in three interaction tasks to evaluate parental scaffolding and parent-child dyadic quality. The parent and child will sit at a small table sitting on adjacent sides of the table to each other (i.e., both in view of cameras and able to make eye-contact with one another). Cardiac physiology (ECG, CO and RSP) and mobile eye-tracking data also will be collected throughout the tasks.

*Book reading task***.** The parent and child look at a wordless book together for four minutes. The book's illustrations depict scenes that elicit both positive (e.g., a child welcoming a new classmate) and negative emotions (e.g., bullying).

Magnet task. The magnet task is a puzzle game intended to assess parental scaffolding. The experimenter will give the participants a box of magnet tiles and a binder with images of different shapes made from the magnet tiles (e.g., a star made by joining a pentagon and five triangles; a cube created by joining together 6 square magnets). Participants are asked to start on the first page of the binder and create as many of the shapes as they can in four minutes. The experimenter informs the parent that the task is primarily for the child, but that the parent may provide as much help as they think their child needs.

Conversation task. The parent and child are asked to face one another and discuss three different topics. First, they will be asked to discuss a negative (i.e., "sad, scary, or angry") experience they had together. Then, they are asked to discuss a positive (i.e., "silly, funny, or happy") experience they had together. Finally, the parent and child are asked to take turns talking about the reasons they love each other. The experimenter leaves the room during the task and knocks every two minutes to indicate when the participants should switch to the next prompt. This task assesses parent-child dyadic quality.

Behavioral inhibition. We assess children's behavioral inhibition through a stranger approach and robot task, which evaluates children's behaviors in response to a novel social interaction (approach by an unfamiliar adult) and a novel non-social object (a dancing toy robot). During the task, the child engages in 1 min of independent play with toys (a Lego Duplo set with ocean animals) in the middle of the room. Parents are instructed to sit in a chair in the corner and avoid interacting with their child. After 1 min, an unfamiliar adult research assistant enters the room, attempts to engage the child in conversation, and offers a new toy (a Lego toy whale belonging to the Duplo set) to the child. The stranger will follow a standardized script, speaking to the child in a neutral tone and wearing standardized attire (a black hat, black t-shirt, and black disposable face mask). The interaction with the "stranger" lasts 2 min, after which the child will be allowed to return to independent play for a minute. Next, the same research assistant will enter the room with a toy robot. The robot dances and plays loud music. The research assistant turns the toy on and leaves. After 1 min, the research assistant returns to the room and engages the child in conversation about the robot, encouraging the child to touch or hold it. The child will not be required to touch the robot if they do not want to.

Rating Behavior

Parent-child interaction tasks. To derive observational scores from parent-child interactions, we will rate behavior using established coding schemes, which have been successfully deployed in numerous longitudinal studies including The Study of Early Childcare and Youth Development and the Family Life Project/ECHO Project (Vernon-Feagans et al., 2013; Vernon-Feagans et al., 2008). Parent, child, and dyadic constructs, such as sensitivity, warmth, intrusion, detachment, positive affect, negative affect, boundary dissolution, and dyadic mutuality, will be derived from these coding schemes. Behavior composites broadly indexing sensitive/responsive (positive) and harsh/controlling (negative) parenting have been established using these coding schemes in multiple studies (Barnett et al., 2008; Vernon-Feagans et al., 2013), and their predictive validity has been established in diverse samples (Brown et al., 2017; Clincy & Mills-Koonce, 2013; Holochwost et al., 2020). Video recordings of the stranger and robot task will be coded in Observer 16 XT by at least two independent raters. Emotion scaffolding, including emotion language use and mental-state language, will be derived from transcripts using the Linguistic Inquiry and Word Count (LIWC) software (Boyd et al., 2022), as well as language style matching, a linguistic metric of dyadic coregulation (Gonzales et al., 2010). The System for Coding Affiliation in Lab Assessments (SCALA) will quantify children's affiliative tenor, including attention towards and awareness of the parent, their social communication, warmth and proximity-seeking, and overall affiliative initiation and enjoyment from the interaction. The SCALA is a newly developed, RDoC-informed coding scheme, designed to assess early individual differences in affiliation as observed in social interactions. Finally, parent-child dyadic synchrony will be assessed using linguistic analysis of transcripts to identify language style concordance between the parent and child, as well as physiological measures of RSA synchrony and coding of mutual eye gaze based on the mobile eye-tracking recordings.

Behavioral inhibition tasks. Observational coding of child responses during the stranger and robot tasks has been reliably used to assess behavioral inhibition in early childhood (Buss, 2011; Buss et al., 2013; Fox et al., 2001; White et al., 2011). Video recordings of the stranger and robot task will be coded in Observer 16 XT by at least two independent raters. The primary variables of interest will be body and facial fear (i.e., slowed rate of play, bodily tension, freezing, and facial expressions), latency to approach and touch the target stimuli (i.e., the toy whale and robot), and proximity to the caregiver and targets (i.e., the stranger and robot). Physiological data (ECG, NICO, and respiration) will be collected for the parent and child throughout the two tasks.

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