HHS Public Access

Author manuscript

J Abnorm Child Psychol. Author manuscript; available in PMC 2015 May 01.

Published in final edited form as:

J Abnorm Child Psychol. 2015 May ; 43(4): 721–734. doi:10.1007/s10802-014-9938-x.

Paths from Mother-Child and Father-Child Relationships to Externalizing Behavior Problems in Children Differing in Electrodermal Reactivity: a Longitudinal Study from Infancy to Age 10

Grazyna Kochanska,
Department of Psychology, University of Iowa, Iowa City, IA 52242-1407, USA

Rebecca L. Brock,
Department of Psychology, University of Iowa, Iowa City, IA 52242-1407, USA

Kuan-Hua Chen,
Department of Neurology, University of Iowa Hospitals and Clinics, 200 Hawkins Dr., Iowa City, IA 52242, USA

Nazan Aksan, and
Department of Neurology, University of Iowa Hospitals and Clinics, 200 Hawkins Dr., Iowa City, IA 52242, USA

Steven W. Anderson
Department of Neurology, University of Iowa Hospitals and Clinics, 200 Hawkins Dr., Iowa City, IA 52242, USA

Abstract

Electrodermal hyporeactivity (or low skin conductance level, SCL) has been long established as a correlate of and diathesis for antisocial behavior, aggression, disregard for rules of conduct and feelings of others, and generally, externalizing behavior problems in children and adults. Much less is known, however, about how individual differences in children's SCL and qualities of their early experiences in relationships with parents interact to produce antisocial outcomes. In a community sample of 102 families (51 girls), we examined children's SCL, assessed in standard laboratory tasks at age 8 (*N*=81), as a moderator of the links between parent–child socialization history and children's externalizing behavior problems at ages 8 and 10, reported by mothers and fathers in well-established instruments and by children in clinical interviews. Mother- and father-child socialization history was assessed in frequent, intensive observations. Parent–child mutually responsive orientation (MRO) was observed from infancy to age 10, parental power assertion was observed from 15 months to age 6 ½, and children reported their attachment security in interviews at age 8 and 10. For children with lower SCL, variations in mothers' power assertion and father-child MRO were associated with parent-rated externalizing problems. The former interaction was

grazyna-kochanska@uiowa.edu.

Conflict of Interest The authors declare that they have no conflict of interest.

consistent with diathesis-stress, and the latter with differential susceptibility. For children with higher SCL, there were no links between socialization history and externalizing problems.

Keywords

Parent–child relationship; Skin conductance level; Externalizing problems; Longitudinal studies

Given the substantial burdens of antisocial behavior for individuals, families, and societies, research on its origins remains a key enterprise in developmental psychology and psychopathology. There is a general consensus that early biologically founded characteristics and early parent–child relationships both play important causal roles in emerging antisocial trajectories (e.g., Deater-Deckard et al. 1998; Dodge et al. 2006; Frick and Morris 2004; Kiff et al. 2011; Kimonis and Frick 2010; Lahey et al. 2008; Nigg 2006; Shaw et al. 1996). As well, there has been an increasing emphasis on multi-level methodologies that include observations, reports, and biological assessments in studies of externalizing problems (Burnette and Cicchetti 2012). Further progress in understanding early developmental origins of antisocial pathways is contingent on an integration of robust observational measures of parent–child relationships, biological assessments, and validated clinical measures of children's outcomes in long-term longitudinal designs.

Multiple large bodies of research robustly support a causal role of early parent–child relationship in antisocial trajectories. There is conceptual and empirical evidence that deficits in early child security, a lack of mutual cooperative, positive early parent–child orientation, and parental reliance on power assertion are risk factors for child conduct problems (e.g., Campbell et al. 2000; Dodge et al. 2006; Dodge and Pettit 2003; Fearon et al. 2010; Gershoff 2002; Patterson et al. 1992; Shaw et al. 2003).

As the emphasis on the interplay of children's early experiences and biological individuality has increased, a growing number of socialization researchers have made contact with the large literature on electrodermal activity (EDA), or more generally, autonomic system functioning. EDA is one aspect of the integrated physiological underpinnings of emotion, arousal, and attention, and is directly controlled by the sympathetic nervous system. It has been suggested that EDA reflects the activation of the behavioral inhibition system, which is involved during negative affect (fear, anxiety, and frustration; Dawson et al. 2007; Fowles 1988). Studies have found that individuals with overall higher levels of EDA tend to be more fearful and anxious. In contrast, those with overall lower levels of EDA tend to be more fearless and impulsive (Block 1957; Fowles et al. 2000). Low levels of EDA are associated with antisocial, externalizing disorders, callousunemotional traits, and insensitivity to punishment (Blair et al. 2006; Fowles and Kochanska 2000; Raine et al. 1990; Dadds and Salmon 2003). Skin conductance level (SCL) is a measure of EDA, reflecting variations in the ease with which electrical current passes across the skin due to fluctuations in sweat gland activity. Low SCL is seen as a correlate of and a psychophysiological diathesis for antisocial externalizing problems (Crowell et al. 2006; Fowles 1993; Lorber 2004; Lykken 1957, 1995; Posthumus et al. 2009; Raine 2002, 2008).

Efforts at the integration of parenting and biology have been also fueled by the rapidly growing work in developmental psychology and psychopathology showing that, generally, children with certain biological characteristics may be more susceptible to effects of socialization or environment. Traditional *diathesis-stress* model focused on children with biological vulnerabilities (e.g., difficult temperament, low SCL). When exposed to negative, unresponsive, harsh parenting, such children are at a considerable risk for externalizing problems. However, warm, mutually responsive parenting that avoids coercion can effectively offset those risks (e.g., Bates and Pettit 2007; Bradley and Corwyn 2008; Mesman et al. 2009).

Recently, researchers have argued for expanding the diathesis-stress approach to include another form of interactions – *differential susceptibility* (Belsky 1997; Belsky et al. 2007; Belsky and Pluess 2009a, b; Boyce and Ellis 2005; Ellis et al. 2011). They proposed that biological vulnerabilities are better described as plasticity or malleability traits rather than risk factors. When subjected to adverse parenting, children with such traits do have worse outcomes than their peers. But given optimal parenting, they can do better than their peers. The differential susceptibility model poses that children who do not have a given vulnerability/plasticity trait are less affected by a range of parenting qualities, adverse or beneficial.

As growing literature has supported both types of interactions in predicting a broad range of developmental outcomes (Belsky and Pluess 2009a, 2009b; Ellis et al. 2011; Fowles and Kochanska 2000), researchers have been urged to include both positive and negative aspects of socialization, because examining positive aspects of parent–child relationships may help reveal the differential susceptibility region of the interaction. Using statistics that distinguish diathesis-stress from differential susceptibility, beyond a visual inspection, is encouraged. We have implemented those guidelines in our work (Kochanska et al. 2011, 2014), and in the present study.

Elucidating the role of children's low SCL as a potential vulnerability factor (diathesis-stress) or plasticity factor (differential susceptibility) in conjunction with the socialization history would be a valuable step toward a comprehensive understanding of risk and resilience in unfolding antisocial trajectories (Blair et al. 2006; Calkins et al. 2013; Dadds and Salmon 2003; Fowles and Kochanska 2000; Frick and Morris 2004; Frick and Viding 2009; Kimonis and Frick 2010; Nigg 2006; Kochanska 1993; Raine 2002). Consequently, individual differences in SCL have been increasingly studied as a moderator of relations between children's socialization histories and externalizing behavior problems. In several studies, low SCL has been conceptualized as a diathesis factor, and negative effects of adverse experiences were found for children with low SCL, but not for those with high SCL. For example, Gregson et al. (2014) found that child-reported victimization was associated with parent- and teacher-reported externalizing problems only for children with low SCL. In that study, all data were concurrent (at age 12). Erath et al. (2009) reported concurrent (at age 8) associations between parent- and child-reported harsh parenting and children's externalizing problems for children with low, but not high, SCL. Following children from age 8 to 10, Erath et al. (2011) found that harsh parenting (reported by parents and children)

in conjunction with low SCL was associated with boys' high and stable level of externalizing behavior.

The findings, however, are not fully consistent. Diamond et al. (2012) reported a complex pattern of results in their study of concurrent associations among adolescents' SCL, single-parent home, and mother-reported externalizing problems. Some effects were found for low and some for high SCL, some for girls and some for boys, and some conforming to diathesis-stress and some – to differential susceptibility. El-Sheikh et al. (2007) also reported a complex pattern in a study of 9-year-olds followed for 2 years. For boys with low SCL, parents' reports of marital conflict predicted increased externalizing symptoms, but the findings differed for girls. In another sample, we focused not on children's externalizing problems, but rather, on their absence (conscience, internalization of conduct rules; Fowles and Kochanska 2000). That study showed that for children with low SCL, but not those with high SCL, mother-child attachment security at age 2 predicted positive conscience development at age 4.

Although valuable, the extant research on children's SCL as a moderator of links between socialization factors and externalizing problems has several limitations: The reliance on reported measures of socialization; a focus on either its negative (harsh control, single parent) or positive aspects (security), but not both; concurrent or very short-term longitudinal designs; the exclusion of fathers; and, with the exception of Diamond et al. (2012), a lack of attention to the form of obtained interactions. In the current study, we address those limitations. We examine the history of both the beneficial and adverse aspects of parent–child socialization, and we use frequent and intensive observations in lengthy naturalistic contexts, in a longitudinal design, with children, mothers, and fathers followed from infancy to age 10.

Unreactive, difficult, fearless, autonomically hypo-aroused children often fail to respond to average parental pressure (e.g., Dadds and Salmon 2003; Briggs-Gowan et al. 2014; Frick and Viding 2009). Given that increasing pressure would be counter-productive, we have posed that, with such children, parents should rely on alternative, positive socialization mechanisms (Kochanska 1993; Fowles and Kochanska 2000). We have examined mutually responsive orientation (MRO) – a close, warm, and mutually cooperative parent–child relationship, and repeatedly shown that it may be especially effective in promoting positive outcomes for children at risk for externalizing problems (Kim and Kochanska 2012; Kochanska, 1997; Kochanska et al. 2008). As well, secure attachment has played a similar role for biologically vulnerable children (Kochanska et al. 2009), including those with low SCL (Fowles and Kochanska 2000). Thus, both MRO and security are strong candidates for revealing differential susceptibility effects.

In this study, we assessed mother- and father-child MRO using observations from 7 months to age 10, and children's security at ages 8 and 10. We also examined mothers' and fathers' power-assertive discipline, the classic risk factor emphasized by virtually all models of externalizing problems, coded in lengthy observations from 15 to 80 months, exclusively in discipline contexts. We assessed externalizing problems twice, at age 8 and 10, using three

informants: mothers, fathers, and children. We deployed extensive data aggregation strategies to produce robust constructs (Rushton et al. 1983).

Based on the extant body of evidence, we expected that SCL, assessed at age 8, would significantly moderate the effects of socialization on externalizing problems at age 8 and 10. We anticipated that children at higher risk for externalizing problems (with low SCL, who respond with less autonomic arousal to standard stimuli) would be more sensitive to variations in their socialization history than children at lower risk (with high SCL). We had no specific expectations regarding the form of the interactions (diathesis-stress versus differential susceptibility). However – and as predicted by both models – we expected that children at high risk (low SCL) who also had adverse socialization histories (adversarial, insecure parent–child relationships, power-assertive control) would have the worst outcomes. We formally tested the form of the interactions to determine whether, given beneficial socialization histories, low-SCL children had no worse outcomes than high-SCL children (diathesis-stress), or better outcomes than high-SCL children (differential susceptibility).

Note that this study involves a low-risk community sample. By and large, parent–child relationships were positive, parenting was adaptive, and children's levels of problem behaviors were low. Consequently, expressions such as "worse outcomes", "adverse socialization history", "high risk", or "power assertion" ought to be viewed as relative. However, examining the processes of development in clinical as well as typical samples is one of the tenets of developmental psychopathology.

Method

Participants

Two-parent community families from a college town, a small city, and rural areas in the Midwest, with normally developing infants (*N*=102), volunteered for this longitudinal study in response to flyers and ads posted broadly in community venues and mailed to day care providers, pediatricians, etc. The families ranged in education. Among mothers, approximately 25 % had a high school education (or less), 54 % had an associate or college degree, and 21 % had a postgraduate education. Among fathers, the respective figures were approximately 30, 51, and 20 %. The annual family incomes ranged from less than $20,000 (8 %), to $20,000–$40,000 (17 %), to $40,000–$60,000 (26 %), to over $60,000 (49 %). Ninety percent of mothers were White, 3 % Hispanic, 2 % African American, 1 % Asian, 1 % Pacific Islander, and 3 % other non-White; 84 % of fathers were White, 8 % Hispanic, 3 % African American, 3 % Asian, and 2 % other. In 20 % of families, one or both parents were non-White. Parents signed informed consent (after age 7, children signed assent).

Overview

Data were collected at Time 1, 7 months (*N*=102, 51 girls), Time 2, 15 months (*N*=101, 51 girls), Time 3, 25 months (age 2, *N*=100, 50 girls), Time 4, 38 months (age 3, *N*=100, 50 girls), Time 5, 52 months (age 4.5, *N*=99, 49 girls), Time 6, 67 months (age 5.5, *N*=92, 45 girls), Time 7, 80 months (age 6.5, *N*=90, 43 girls), Time 8, 100 months (age 8, *N*=87, 41

girls), and at Time 9, 123 months (age 10, *N*=82, 37 girls). Each time included lengthy (2–4 hr) observational video-recorded sessions in a developmental psychology laboratory, one with each parent, conducted by female experimenters, Es (at Time 1, the sessions were at home; at Time 4, at home and in the laboratory; at Time 8, there were no parent–child observations, and the assessments focused on the child). The laboratory includes a naturalistic living room and a play room. The living room contains a table with attractive toys, designated as off-limits to the child, and parents were asked to state the rule at the outset and enforce it throughout the session. Those sessions produced observational data on children's MRO with their mothers and fathers and on each parent's power-assertive control. At Times 8 and 9, mothers and fathers rated children's externalizing behavior problems on well-established instruments, and children reported their behavior problems and their perception of attachment security to each parent in individual interviews.

Data on skin conductance level (SCL) were obtained at age 8 from a subset of 81 children (37 girls), who agreed to psychophysiological testing. There were no significant differences between the families whose children did and did not have valid SCL data with regard to mother- or father-child MRO, power assertion, or parent- or child-reported externalizing problems. The one exception was child-reported security: Children who did not have SCL data reported more security with both parents, $p<0.05$.

All behavioral data were coded from videotapes (or digital records). Reliability was typically established on 15–20 % of cases, followed by frequent realignments to prevent observer drift. Kappas, weighted kappas, and alphas or intra-class correlations, ICCs (*N*ote that the best practices have evolved over the last 10 years) were used. Because the behavioral constructs have been published previously (e.g., Kochanska et al. 2014; Kochanska and Kim 2012), the current description is abbreviated (for details, please contact the first author).

Measures of Mother-Child and Father-Child MRO

Observed contexts Positive, mutually responsive parenting (MRO) for each parent–child dyad was observed in naturalistic, carefully scripted, developmentally appropriate contexts, such as play, snack, care routines, parent busy, chores (toy cleanup), opening a gift together, and at older age, parent– child discussions, joint problem solving, etc. The observed times coded for each parent–child dyad for Times 1, 2, 3, 4, 5, 6, 7, 9 were 34, 42, 47, 77, 65, 60, 60, and 81 min respectively (total 7 h 46 min).

Coding and data aggregation—Coders rated each dyad using items that ranged from "1" (very untrue of the dyad) to "5" (very true of the dyad). They considered the degree to which the dyad's routines were smooth and coordinated, the quality of dyadic communication, the degree of mutual cooperation, and emotional ambience of the interaction. *Coordinated routines* were coded as low when the dyad had no routines, or routines were choppy, rough, and conflict producing, and as high when the dyad easily settled into comfortable, coordinated routines. *Harmonious communication* was scored as low when the dyad communicated very little or not at all, and as high when they communicated smoothly, in a connected and harmonious manner. *Mutual cooperation* was

coded as low when the dyad was unable to cooperate, and struggles and conflicts escalated, and as high when the parent and child adopted a willing, receptive stance toward each other, and subtle cues were sufficient to elicit cooperation. *Emotional ambience* was coded as low when the affective climate was negative, with bouts of negative affect, and as high when the parent and child enjoyed each other, the climate was positive and warm, with bouts of joy, good humor, and affection. Across multiple coding teams, reliability, average weighted kappa, ranged from 0.72 to 0.83.

The scores were first aggregated for each of the observed contexts, and then across all observed contexts (starting at Time 4, the coding was simplified, but remained fully parallel; one overall MRO code was given for each context). They cohered substantially. Cronbach's alphas were as follows (mother-child first, father-child second): Time 1, 0.80, 0.79; Time 2, 0.86, 0.81, Time 3, 0.82, 0.82, Time 4, 0.72, 0.79, Time 5, 0.79, 0.75, Time 6, 0.81, 0.78, Time 7, 0.76, 0.78, Time 9, 0.91, 0.88. Thus, they were averaged across all contexts into one MRO score for each parent at each time. Those scores cohered across Times 1–9, alphas 0.85 and 0.84, and were averaged in one overall MRO score for each parent– child dyad.

Measures of Children's Security with Mothers and Fathers

At Times 8 and 9, children completed the Kerns Security Scale (KSS, Kerns et al. 1996), a 15-item questionnaire to assess children's perceptions of security in their relationships with their mothers and fathers. E read the questionnaire to the child, without the parent present, and the child indicated, first, which description of each item was most like the child, and second, whether this description was "very true" or "sort of true". One item states, for example: Some kids are really sure their mom would not leave them BUT other kids sometimes wonder if their mom might leave them. Each item is scored from 1 to 4. The scores were tallied. Cronbach's alphas were 0.67 and 0.68 at Time 8, and 0.74 and 0.73 at Time 9 for security with mothers and fathers, respectively. Those scores were averaged across Times 8 and 9 into one overall security score for each parent.

Measures of Mothers' and Fathers' Power-Assertive Control

Observed contexts—Each mother- and father-child dyad were observed in Do control context (when the parent requested that the child pick up all the many toys scattered after play) and several Don't contexts (the periods in the laboratory room when the extremely attractive, prohibited objects and toys were easily accessible to the child). The observed contexts partly overlapped with those of MRO, but were coded by independent teams. Those data were collected at Times 2, 3, 4, 5, 6, and 7 (the observed times for each parent–child dyad were 42, 47, 42, 75, 70, and 70 min respectively; 5 h 46 min total).

Coding—The approach to coding and aggregation has been published (e.g., Kochanska et al. 2014). Parental style of control was coded for each 30-s segment (for Do, throughout the toy cleanup; for Don't, following every instance once the parent and/or child became involved with the prohibited objects). For each segment, coders made global ratings and coded all physical techniques. The global ratings included: no interaction, social exchange (sociable interaction but no control), gentle guidance (parent hints, suggests), control (parent controls in an assertive, firm manner, with direct commands and prohibitions, e.g., no!, we

are not playing now; those are only for looking), and forceful, negative control (parent uses threats, negative, angry control, commands or prohibitions issued in a raised or irritated voice, negatives, e.g., stop this minute!; clean up right now or no pool today; what did I tell you?; will you listen!) . Reliability, average kappas across multiple teams of coders, ranged from 0.76 to 0.94. The physical techniques included assertive interventions (holding the child's hand firmly, physically preventing child from leaving the chore, blocking access to toys) and forceful interventions (yanking a toy away, handling the child roughly). Reliability, average kappas, ranged from 0.66 to 1.00

Data aggregation—For each context (Do and Don't), the instances of each code were tallied and divided by the number of coded segments. We then applied weights to those scores to reflect the amount parental power, as follows: −2 to no interaction, −1 to social exchange, 1 to gentle guidance, 2 to control, 3 to forceful control, 4 to physical assertive, and 5 to physical forceful. Those weighted figures were summed into one weighted power assertion composite for Do and one for Don't, for each mother and each father. Those two scores were standardized and averaged into one power assertive control score. Those scores cohered longitudinally across Times 2–7, alphas 0.75 and 0.76, and were thus averaged into an overall power assertion score for each parent.

Measures of Children's Skin Conductance Level, Age 8

Procedure—Data on children's SCL were obtained in five tasks, presented in fixed order, listed below. To prevent excessive motion during the tasks, the children were allowed to move around, wiggle, or readjust themselves before each task began, and then instructed to sit still and watch a computer screen that cycled through abstract pictures during the first four tasks. The tasks were as follows. (1) Rest 1, 3 min. The child was asked to relax and open and close their eyes every 30 s (as probed by the experimenter). (2) Deep breathing, 2 min. The child took a deep breath every time he or she heard a beep (five deep-breathing probes with a fixed interval of 20 s). (3) Startle, 3 min. The child was presented with eight acoustic startle probes (90 db white noise, 500 ms, with the intervals between the probes lasting 15–25 s). (4) Rest 2, 3 min, identical to Rest 1. (5) Gift anticipation, 2 min. The child was asked to wait for a gift while a timer on the computer screen showed the countdown.

Data acquisition—SCL data were acquired using BIOPAC MP100 system at the sampling rate of 1,000 Hz. Two Ag/AgCl electrodes were placed on the thenar and hypothenar eminences of the child's left hand. Due to procedural errors or poor data quality, SCL data from seven subjects were excluded. SCL data were first down-sampled to 100 Hz (centisecond); artifacts were identified manually by a trained research assistant blind to hypotheses, and corrected using Ledalab software (Benedek and Kaernbach 2010). Centisecond-by-centisecond SCL data were averaged for each task, and then were log-transformed. Data from tasks 2–5 were aggregated (Cronbach's alpha=0.94). Rest 1 was excluded to allow for full hydration (Fowles 2008).

Measures of Children's Externalizing Problems, Age 8 and Age 10

Parent-Reported Instruments

Child Symptoms Inventory-4 (CSI-4): At ages 8 and 10, parents rated children's externalizing problems in CSI-4 (Gadow and Sprafkin 2002; Gadow et al. 2001; Sprafkin et al. 2002). We selected Oppositional Defiant Disorder (ODD; e.g., defies, refuses, deliberately annoys, 8 items, alphas at age 8, for mothers and fathers, 0.86 and 0.83, at age 10, 0.85,0.89) and Conduct Disorder (CD; e.g., bullies others, lies, 15 items, alphas at age 8, both 0.67, at age 10, 0.77, 0.59), and used the Symptom Severity scoring, with each item rated from 0 (*N*ever) to 3 (very often). At each age, the two scores were added into one CSI-4 child externalizing behavior problems score for each parent.

MacArthur Health Behavior Questionnaire (HBQ): Also at 8 and 10, parents completed HBQ (Boyce et al. 2002; Essex et al. 2002). We selected the Overt Aggression scale (4 items rated from "1", never/not true to "3", often/very true); alphas for mothers and fathers, 0.62 and 0.57 at age 8, and 0.56 and 0.58 at age 10.

Data Aggregation—At each age (8 and 10), we averaged the four scores – mother and father CSI-4 externalizing problems, and mother and father HBQ Overt Aggression scores – into one overall child externalizing behavior problems score (all standardized, because they came from different instruments). Those scores cohered (alphas 0.77 and 0.80 at age 8 and 10, respectively), and correlated across two ages, $r(82)=0.82$, $p<0.001$, and thus were averaged into the final parent-rated externalizing behavior problems scores from age 8 to age 10.

Child Self-Reported Instrument—At each age (8 and 10), during the visits in the developmental psychology laboratory, having established good rapport with E, children participated in the interactive, computerized clinical interview, Dominic-R, an approximately 30-min, vignette-based, visual-auditory instrument. It was developed for children aged 6 to 11, designed to map onto DSM-IV disorders, and its reliability and validity have been established in many large studies (e.g., Arseneault et al. 2005; Bergeron et al. 2000; Breton et al. 1999; Shojaei et al. 2009; Valla et al. 1994, 2000). The vignettes depict specific behavior problems. The child endorses each vignette as descriptive of him or her (yes/no). At both age 8 and 10, we used the broad-band externalizing problem scores produced by the computer program (oppositional defiant disorder, conduct disorder, attention deficit/hyperactivity disorder, Valla 2000).

Data Aggregation—The externalizing problem scores at age 8 and 10 correlated, $r(79)=0.31$, $p<0.01$, and were averaged into one final child self-reported externalizing behavior problems score from age 8 to age 10. Parent- and self-reported scores modestly correlated, $r\ (86)=0.29$, $p<0.01$. All descriptive data are in Table 1.

Results

Preliminary analyses

Correlations between socialization and SCL measures and child externalizing outcomes are in Table 2. The correlations are presented for all children and separately for those with low and high SCL scores (below and above the median). For the entire sample, mothers' and fathers' power assertion was positively associated with children's externalizing problems, both parent- and self-reported, and MRO was negatively associated with parent-reported problems (for mother-child dyads, also with child selfreported problems). Children's security with both mothers and fathers was associated with fewer child self-reported problems. SCL did not correlate with measures of problems.

The patterns, however, appeared somewhat different for low- and high-SCL children. All significant correlations with parent-reported problems were for the low-SCL children, and none were significant for the high-SCL children. The pattern was much the same for child-reported problems, with two exceptions: The links with paternal power assertion and security with the mother were significant for both groups.

Parent–child MRO, security, parental power assertion, and SCL as predictors of children's externalizing problems: Multiple regressions

We conducted four multiple regressions. Two equations (for mother-child dyads and father-child dyads), examined the predictors of parent-rated externalizing behavior problems. Two parallel equations examined the predictors of children's self-rated externalizing problems. Significant interaction effects were probed using simple slopes (Aiken and West 1991).

To distinguish diathesis-stress from differential susceptibility, we further examined the significant interaction effects using a relatively new formal approach to the testing of interactions that involves the analysis of regions of significance (Aiken and West 1991; Hayes and Matthes 2009; Preacher et al. 2006). We have used this approach toward a similar goal (Kochanska et al. 2011, 2014). This strategy has been since advocated as particularly appropriate for distinguishing differential susceptibility from diathesis–stress (Roisman et al. 2012). The regressions (the final step with all the predictors entered) are in Table 3.

In each regression, the order of entry was as follows: Step 1, child gender (0=girl, 1=boy), and mother and father education level (1=less than high school to 5=more than college); Step 2, the given parent–child MRO, security, and power assertion, and the child's SCL (0=low, 1=high); Step 3, three interactions, MRO × SCL, security × SCL, and power assertion × SCL.

For *parent-rated externalizing behavior problems*, there were two significant interactions involving SCL, one for each relationship. For *mother-child dyads*, the interaction between maternal power-assertive control and SCL was significant (graphed in Fig. 1). For children who had low SCL scores, the simple slope of maternal power assertion (the composite from 15 months to age 6 ½) on child externalizing problems at 8–10 was significant, b=0.30, SE=0.14, p<0.05; for those children, variation in maternal power assertion was associated with differences in their externalizing problems. The low-SCL children who had received

highly power-assertive maternal discipline had particularly high externalizing problems scores, but those who had received little power assertion had low scores. Maternal power assertion was unrelated to externalizing problems for children with high SCL scores, b= −0.30, SE=0.25, ns.

The regions-of-significance analysis revealed a pattern consistent with diathesis-stress. The lower and upper bounds of the regions of significance were, respectively, −4.01 SDs (thus of no practical significance) and 0.56 SD. This indicated that the two regression lines were significantly different for all possible points when the score of maternal power assertion was higher than approximately ½ SD. The shaded area of Fig. 1 represents this region of significance. Children with low SCL who had received more maternal power assertion in the first 6 years of life were seen as having worse outcomes – significantly more externalizing problems – than their peers with high SCL, who received comparable amount of power assertion. The low-SCL children who had received little power assertion did no worse (but not better) than their high-SCL peers.

For *father-child dyads*, the interaction between MRO and SCL was significant (graphed in Fig. 2). For children who had low SCL scores, the simple slope of father-child MRO (the composite from infancy to age 10) on child externalizing problems at 8–10 was significant, b = − 0.45, SE = 0.15, p<0.005; for those children, variation in MRO was predictive of differences in their externalizing problems. The low-SCL children who enjoyed a highly positive relationship with their fathers had low externalizing problems scores, but those who had lacked such a relationship had high scores. Father-child MRO was unrelated to externalizing problems for children with high SCL scores, b=0.01, SE=0.13, ns.

The regions-of-significance analysis revealed a pattern of differential susceptibility. The lower and upper bounds of the regions of significance were, respectively, −1.11 and +1.59, and thus the two regression lines were significantly different for all possible points when the score of father-child MRO was lower than approximately 1 *SD* or higher than approximately 1½ *SD*. The shaded areas of Fig. 2 represent the regions of significance. Children with low SCL who had low scores of father-child positive relationship had worse outcomes – significantly more externalizing problems – than their peers with high SCL, who had comparable relationships with their fathers. But children with low SCL who had highly positive relationships with their fathers did better – had fewer problems – than high-SCL children in comparable relationships.

For children's externalizing behavior problems reported during the clinical interviews at age 8 and 10, there were main effects only. Higher power assertion, from both mothers and fathers, was associated with children reporting more externalizing problems. Also, children who perceived their relationships with fathers as more secure reported fewer problems (the parallel effect for security with mothers was marginal).

Discussion

This study makes several useful contributions to the growing research on the interplay of biology and socialization in the emergence of externalizing behavior problems. This work

has several strengths. We have followed the families from infancy to age 10; we included children, mothers, and fathers; we examined uniquely frequent and intensive behavioral data on socialization history that included measures of both positive reciprocity and mutuality (MRO) and security, and of power-assertive control, thus assessing several broad domains of socialization (Bugental and Grusec 2006). We collected measures of externalizing problems at age 8 and 10 from the parents and children, and measures of SCL at age 8, using a standard protocol (Dawson et al. 2007). And, with the exception of children's reports of security and their reports of externalizing problems, no other measures were subject to shared method variance, a common problem in the extant research on socialization × SCL interactions. The examined significant interactions between socialization factors and SCL were situated in the context of the recent growing focus on diathesis-stress versus differential susceptibility. Illustrating the principle of multifinality in developmental psychopathology (Cicchetti and Rogosch 1996), the findings suggest a possibility of remarkably diverse developmental trajectories for children at high physiological risk, contingent on the type of socialization histories they experience.

As a general caveat, the very issue of what constitutes diathesis or vulnerability in skin conductance research is complex. Generally, in clinical research, *low SCL* has been robustly related to antisocial, externalizing disorders. In developmental psychology, it has been linked to fearlessness and disinhibition, callous-unemotional traits, insensitivity to punishment, and unresponsiveness to parents' average level of control and usual parenting influence (Blair et al. 2006; Dadds and Salmon 2003; Fowles and Kochanska 2000; Frick and Morris 2004; Hinshaw and Anderson 1996; Lytton 1990). However, there is also a body of research focused on high SCL as a diathesis for poor emotion regulation, poor coping, and a host of behavior problems. In the latter literature, children with *high SCL* are seen as more sensitive to context and more susceptible to environmental influences (Belsky and Pluess 2009a; Diamond et al. 2012; Ellis et al. 2011). This complex issue deserves much more research attention; it is possible that low SCL should be seen as moderating effects of socialization on externalizing, antisocial outcomes, whereas high SCL – as moderating effects on internalizing outcomes, such as depression and anxiety. In the present study, however, because of our focus on externalizing behaviors – ODD, CD, aggression — as outcomes, we adopted the view that children's tendency to respond with under-arousal (low SCL) to stimuli is a marker of vulnerability (or plasticity) with regard to externalizing behavior problems. Our data show that for low-SCL children, variations in maternal control and in father-child MRO are related to externalizing problems, but no links between socialization history and outcomes were found for high-SCL children. Perhaps for high-SCL children, variations in socialization history would relate to depression and anxiety. This is a worthwhile question for future research.

Our results are quite clear. Variations in socialization histories had no implications for high-SCL children. For father-child dyads, we replicated and extended our earlier findings (Fowles and Kochanska 2000). That earlier study found that for low-SCL children, mother-child attachment security predicted future development of mature conscience. In the present study, the low-SCL children who had developed low level of MRO with their fathers over the first 10 years had the worst outcomes (more externalizing problems), but those who had

developed a high MRO had better outcomes (fewer problems) than their high-SCL peers, thus consistent with differential susceptibility. This finding is consistent with our theory and earlier conceptual and empirical model of positive socialization forces being particularly effective for children who are fearless or disinhibited (Kochanska 1993; Kochanska et al. 2007). For such children, punishment-based strategies may be ineffective; however, alternative strategies that capitalize on positive mutuality, children's positive emotion, and their willing embrace of parental standards of conduct may lead to adaptive developmental trajectories.

Finding the MRO × SCL interaction only for fathers and children is intriguing. Compared to mothers, fathers tend to engage in higher-intensity play and more boisterous activities with their children (Parke and Buriel 2006). Perhaps they find low-SCL children – often fearless, adventurous, bold, and outgoing – to be more compatible partners than high-SCL children – often more fearful, risk averse, and inhibited. Consequently, fathers and low-SCL children might form a particularly enjoyable, connected, and close mutually responsive orientation, thus rendering the child especially receptive to socialization and eager to embrace standards of conduct. If replicated, such a model would explain why low-SCL children who have especially good relationships with their fathers have significantly fewer externalizing problems than their high-SCL peers. The finding of the key importance of the father-child MRO for children at relatively higher risk is particularly noteworthy, with potential implications for family prevention programs.

For mothers and children, we found that for low-SCL children, history of maternal reliance on power-assertive discipline had detrimental effects. The findings were consistent with diathesis-stress: The low-SCL children who had a history of maternal power-assertive discipline had most externalizing problems at age 8–10, but if they received little coercion, they had outcomes comparable to (but not better than) their high-SCL peers. This result replicates similar findings in the past studies, despite differences in methodologies (Erath et al. 2009, 2011). Erath and colleagues relied on parent and child reports of harsh discipline, and they studied 8–9-year-old children. We observed parents' discipline from the typical age of onset (15 months) to age 6 ½, in challenging control contexts (toy cleanup, prohibition to touch certain objects). Consequently, the replication is noteworthy.

It is unclear why a similar interaction was not found for fathers and children. Perhaps it is due to the mean differences between parents. We decomposed the overall power assertion scores at each age into two scores before standardization (for Do and Don't contexts), and found that at five of the six assessments, mothers used significantly more power in Don't context (although note that the use of power was overall quite low).

We obtained socialization × SCL interactions for parent-rated outcomes only, consistent with the possibility that parents' and children's reports, although modestly correlated, may provide unique windows (De Los Reyes and Kazdin 2004). But notably, and consistent with the extant literature, history of power assertion with either parent positively predicted children's reported externalizing problems. One potential explanation might be that children who are more difficult and defiant, and thus already at risk for future behavior problems, receive more power-assertive discipline. Because observed data on children's defiance at the

point of onset of control (15 months) were available, to reduce such possibility, we conducted all regressions controlling for those scores; the findings were unchanged.

It was also notable that children's concurrent security with the fathers (and marginally with the mothers) was negatively related to their reported behavior problems. However, because both measures came from the same informants, those relations need to be treated with caution.

This study has several limitations. Given that the families had been followed for 10 years, the final sample was relatively small. The children were typically developing and generally well functioning, and their levels of externalizing problems were relatively low and, by and large, in the normative range. We believe that our approach to children's externalizing problems that relies on extensive data aggregation has resulted in reasonable distributions. Our constructs included symptoms of ODD, CD, and aggression, averaged across the two times of assessments (and across two informants for parental reports). We are, however, mindful of the nature of the sample and of our limited ability to generalize the findings to children whose externalizing problems are in the clinical range. As well, the parent–child relationships were typically positive, and parental use of power assertion in our observed paradigms was low. The latter is a well-known, challenging issue in observational research, handled in a variety of ways (Joosena et al. 2012). Our overall weighted power assertion composite, assigning lower weights to behaviors that entail no or little power and higher weights to more forceful ones, assures well-distributed measures of the varying amount of pressure parents apply across multiple control episodes. As well, the frequent and intensive observations across six assessments generated measures that were more robust than those typically reported.

It is noteworthy, and meaningful from the perspective of developmental psychopathology, that significant findings nevertheless emerged in this highly functioning population. We do, however, acknowledge a limited ability to generalize our findings to high-risk populations, in which children have clinically elevated disruptive, antisocial behavior scores and parents' socialization practices are harsh, unresponsive, and rejecting. It will be important to replicate the findings in such populations. The effects may well prove to be stronger. It will also be important to replicate the findings in more ethnically diverse families. There is considerable evidence that effects of power assertion on externalizing problems vary across ethnic groups (Deater-Deckard et al. 1996; Lansford et al. 2004). Consequently, replications will be essential.

Having only one assessment of SCL was a limitation. For logistical reasons, we were only able to conduct one psychophysiological session. El-Sheikh (2007) reported that SCL appears to reflect stable individual differences, at least between ages 6 and 13. But given that SCL is often seen as a physiological correlate of responsiveness to socialization (Briggs-Gowan et al. 2014; Dadds and Salmon 2003), it is possible that assessing SCL and socialization factors concurrently and repeatedly would produce stronger findings. As well, externalizing behavior was assessed in part concurrently to SCL (but recall the construct incorporated also data obtained 2 years later, at age 10). Having several future assessments of outcomes would strengthen the inferences about developmental trajectories. Nevertheless,

despite the limitations, this study makes useful contributions to our understanding of basic processes of socialization and origins of adaptive and maladaptive developmental cascades. If replicated, it has a potential to inform prevention and intervention efforts, including specific guidance for mothers and fathers of young children at risk for disruptive, antisocial, and externalizing behavior problems.

Acknowledgments

This research has been funded by the National Institute of Mental Health (R01 MH63096, K02 MH01446) and National Institute of Child Health and Human Development (R01 HD069171), and by Stuit Professorship to Grazyna Kochanska. We thank Kate Keenan for her guidance with regard to the assessment of children's externalizing problems. We also thank many colleagues, students, and staff, especially Lea Boldt, Sanghag Kim, Jarilyn Akabogu, Jeung Eun Yoon, Jessica O'Bleness, Robert Marini, and Amanda Grafft for their help with data collection and data management, and all parents and children in Family Study for their commitment.

References

Aiken, LS.; West, SG. Multiple regression: Testing and interpreting interactions. Sage; Newbury: 1991.

Arseneault L, Kim-Cohen J, Taylor A, Caspi A, Moffitt TE. Psychometric evaluation of 5- and 7-year old children's self-reports of conduct problems. Journal of Abnormal Child Psychology. 2005; 33:537–550. [PubMed: 16195949]

Bates, JE.; Pettit, GS. Temperament, parenting, and socialization. In: Grusec, JE.; Hastings, PD., editors. Handbook of socialization: Theory and research. Guilford; New York: 2007. p. 153-77.

Belsky J. Variation in susceptibility to rearing influences: an evolutionary argument. Psychological Inquiry. 1997; 8:182–186.

Belsky J, Pluess M. Beyond diathesis-stress: differential susceptibility to environmental influences. Psychological Bulletin. 2009a; 135:885–908. [PubMed: 19883141]

Belsky J, Pluess M. The nature (and nurture?) of plasticity in early human development. Perspectives on Psychological Science. 2009b; 4:345–351.

Belsky J, Bakermans-Kranenburg MJ, van Ijzendoorn MH. For better and for worse: differential susceptibility to environmental influences. Current Directions in Psychological Science. 2007; 16:300–304.

Benedek M, Kaernbach C. A continuous measure of phasic electrodermal activity. Journal of Neuroscience Methods. 2010; 190:80–91. [PubMed: 20451556]

Bergeron L, Valla JP, Breton JJ, Gaudet N, Berthiaume C, Lambert J, Smolla N. Correlates of mental disorders in the Quebec general population of 6 to 14-year-olds. Journal of Abnormal Child Psychology. 2000; 28:47–62. [PubMed: 10772349]

Blair RJR, Peschardt KS, Budhani S, Mitchell DGV, Pine DS. The development of psychopathy. Journal of Child Psychology and Psychiatry. 2006; 47:262–275. [PubMed: 16492259]

Block J. A study of affective responsiveness in a lie-detection situation. Journal of Abnormal and Social Psychology. 1957; 55:11–15.

Boyce WT, Ellis BJ. Biological sensitivity to context: I. An evolutionary– developmental theory of the origins and functions of stress reactivity. Development and Psychopathology. 2005; 17:271–301. [PubMed: 16761546]

Boyce WT, Essex MJ, Woodward HR, Measelle JR, Ablow JC, Kupfer DJ. The confluence of mental, physical, social and academic difficulties in middle childhood. I: exploring the "headwaters" of early life morbidities. Journal of the American Academy of Child & Adolescent Psych iatry. 2002; 41:580–587.

Bradley RH, Corwyn RF. Infant temperament, parenting, and externalizing behavior in first grade: a test of the differential susceptibility hypothesis. Journal of Child Psychology and Psychiatry. 2008; 49:124–131. [PubMed: 18211274]

Breton JJ, Bergeron L, Valla JP, Berthiaume C, Gaudet N, Lambert J, Lepine S. Quebec child mental health survey: prevalence of DSM-III-R mental health disorders. Journal of Child Psychology and Psychiatry. 1999; 40:375–384. [PubMed: 10190339]

Briggs-Gowan MJ, Nichols SR, Voss J, Zobel E, Carter AS, McCarthy KJ, Pine DS, Blair J, Wakschlag LS. Punishment insensitivity and impaired reinforcement learning in preschoolers. Journal of Child Psychology and Psychiatry. 2014; 55:154–161. [PubMed: 24033313]

Bugental, DB.; Grusec, JE. Socialization processes. In: Damon, W.; Lerner, RM.; Eisenberg, N., editors. Handbook of child psychology: Vol. 3. Social, emotional, and personality development. Wiley; New York: 2006. p. 366-428.

Burnette ML, Cicchetti D. Multilevel approaches toward understanding antisocial behavior: current research and future directions. Development and Psychopathology. 2012; 24:703–704. [PubMed: 22781849]

Calkins SD, Propper C, Mills-Koonce WR. A biopsychosocial perspective on parenting and developmental psychopathology. Development and Psychopathology. 2013; 25:399–1414.

Campbell SB, Shaw DS, Gilliom M. Early externalizing behavior problems: toddlers and preschoolers at risk for later maladjustment. Development and Psychopathology. 2000; 12:467–488. [PubMed: 11014748]

Cicchetti D, Rogosch FA. Equifinality and multifinality in developmental p sychopatholog y. Development and Psychopathology. 1996; 8:597–600.

Crowell SE, Beauchaine TP, Gatzke-Kopp L, Sylvers P, Mead H, Chipman-Chacon J. Autonomic correlates of attention-deficit/hyperactivity disorder and oppositional defiant disorder in preschool children. Journal of Abnormal Psychology. 2006; 115:174–178. [PubMed: 16492108]

Dadds MR, Salmon K. Punishment insensitivity and parenting: temperament and learning as interacting risks for antisocial behavior. Clinical Child and Family Psychology Review. 2003; 6:69–86. [PubMed: 12836578]

Dawson, ME.; Schell, AM.; Filion, DL. The electrodermal system. In: Cacioppo, JT.; Tassinary, LG.; Berntson, G., editors. Handbook of Psychophysiology. 3rd. Cambridge University Press; New York: 2007. p. 159-181.

De Los Reyes A, Kazdin AE. Measuring informant discrepancies in clinical child research. Psychological Assessment. 2004; 16:330–334. [PubMed: 15456389]

Deater-Deckard K, Dodge KA, Bates JE, Pettit GS. Physical discipline among African American and European American mothers: links to children's externalizing behaviors. Developmental Psychology. 1996; 32:1065–1072.

Deater-Deckard K, Dodge KA, Bates JE, Pettit JE. Multiple risk factors in the development of externalizing behavior problems: group and individual differences. Development and Psychopathology. 1998; 10:469–493. [PubMed: 9741678]

Diamond LM, Fagundes CP, Cribbet MR. Individual differences in adolescents' sympathetic and parasympathetic functioning moderate associations between family environment and psychosocial adjustment. Developmental Psychology. 2012; 48:918–931. [PubMed: 22268602]

Dodge KA, Pettit GS. A biopsychosocial model of the development of chronic conduct problems in adolescence developmental psychology. Developmental Psychology. 2003; 39:349–371. [PubMed: 12661890]

Dodge, KA.; Coie, JC.; Lynam, D. Aggression and antisocial behavior in youth. In: Damon, W.; Lerner, RM.; Eisenberg, N., editors. Handbook of child psychology Social, emotional, and personality development. Wiley; New York: 2006. p. 719-788.

Ellis BJ, Boyce WT, Belsky J, Bakermans-Kranenburg MJ, van Ijzendoorn MJ. Differential susceptibility to the environment: an evolutionary–neurodevelopmental theory. Development and Psychopathology. 2011; 23:7–28. [PubMed: 21262036]

El-Sheikh M. Children's skin conductance level and reactivity: are these measures stable over time and across tasks? Developmental Psychobiology. 2007; 49:180–186. [PubMed: 17299790]

El-Sheikh M, Keller PS, Erath SA. Marital conflict and risk for child maladjustment over time: skin conductance level reactivity as a vulnerability factor. Journal of Abnormal Child Psychology. 2007; 35:715–727. [PubMed: 17503176]

Erath SA, El-Sheikh M, Cummings EM. Harsh parenting and child externalizing behavior: skin conductance level reactivity as a moderator. Child Development. 2009; 80:578–592. [PubMed: 19467012]

Erath SA, El-Sheikh M, Hinnant JB, Cummings EM. Skin conductance level reactivity moderates the association between harsh parenting and growth in child externalizing behavior. Developmental Psychology. 2011; 47:693–706. [PubMed: 21142369]

Essex MJ, Boyce WT, Goldstein LH, Armstrong JM, Kraemer HC, Kupfer DJ. The confluence of mental, physical, social and academic difficulties in middle childhood II: developing the MacArthur health and behavior questionnaire. Journal of the American Academy of Child & Adolescent Psychiatry. 2002; 41:588–603. [PubMed: 12014792]

Fearon RMP, Bakermans-Kranenburg MJ, van IJzendoorn MH, Lapsley AM, Roisman GI. The significance of insecure attachment and disorganization in the development of children's externalizing behavior: a meta-analytic study. Child Development. 2010; 81:435–456. [PubMed: 20438450]

Fowles DC. Psychophysiology and psychopathology: a motivational approach. Psychophysiology. 1988; 25:373–391. [PubMed: 3051073]

Fowles, DC. Electrodermal activity and antisocial behavior: Empirical findings and theoretical issues. In: Roy, JC.; Boucsein, W.; Fowles, DC.; Gruzelier, JH., editors. Progress in electrodermal research. Springer; New York: 1993. p. 223-237.

Fowles, DC. The measurement of electrodermal activity in children. In: Schmidt, LA.; Segalowitz, SJ., editors. Developmental psychophysiology: Theory, systems, and methods. Cambridge University Press; New York: 2008. p. 286-316.

Fowles DC, Kochanska G. Temperament as a moderator of pathways to conscience in children: the contribution of electrodermal activity. Psychophysiology. 2000; 37:788–795. [PubMed: 11117459]

Fowles DC, Kochanska G, Murray K. Electrodermal activity and temperament in preschool children. Psychophysiology. 2000; 37:777–787. [PubMed: 11117458]

Frick PJ, Morris AS. Temperament and developmental pathways to conduct problems. Journal of Clinical Child and Adolescent Psychology. 2004; 33:55–68.

Frick PJ, Viding E. Antisocial behavior from a developmental psychopathology perspective. Development and Psychopathology. 2009; 21:1111–1131. [PubMed: 19825260]

Gadow, KD.; Sprafkin, J. Child Symptom Inventory-4: Screening and norms manual. Checkmate Plus; Stony Brook: 2002.

Gadow KD, Sprafkin J, Nolan EE. DSM-IVsymptoms in community and clinic preschool children. Journal of the American Academy of Child and Adolescent Psychiatry. 2001; 40:1383–1392. [PubMed: 11765283]

Gershoff ET. Corporal punishment by parents and associated child behaviors and experiences: a meta-analytic and theoretical review. Psychological Bulletin. 2002; 128:539–579. [PubMed: 12081081]

Gregson KD, Tu KM, Erath SA. Sweating under pressure: skin conductance level reactivity moderates the association between peer victimization and externalizing behavior. Journal of Child Psychology and Psychiatry. 2014; 55:22–30. [PubMed: 23734821]

Hayes AF, Matthes J. Computational procedures for probing interactions in OLS and logistic regression: SPSS and SAS implementations. Behavior Research Methods. 2009; 41:924–936. [PubMed: 19587209]

Hinshaw, SP.; Anderson, CA. Conduct and oppositional defiant disorders. In: Mash, EJ.; Barkley, RA., editors. Child psychopathology. Guilford Press; New York: 1996. p. 113-149.

Joosena KJ, Mesman J, Bakermans-Kranenburg MJ, van IJzendoorn MH. Maternal sensitivity to infants in various settings predicts harsh discipline in toddlerhood. Attachment and Human Development. 2012; 14:101–117. [PubMed: 22385309]

Kerns KA, Klepac L, Cole A. Peer relationships and preadolescents' perceptions of security in the child-mother relationship. Developmental Psychology. 1996; 32:457–466.

Kiff CJ, Lengua LJ, Zalewski M. Nature and nurturing: parenting in the context of child temperament. Clinical Child and Family Psychology Review. 2011; 14:251–301. [PubMed: 21461681]

Kim S, Kochanska G. Child temperament moderates effects of parent–child mutuality on self-regulation: a relationship-based path for emotionally negative infants. Child Development. 2012; 83:1275–1289. [PubMed: 22670684]

Kimonis, ER.; Frick, PJ. Etiology of oppositional defiant disorder and conduct disorder: Biological, familial and environmental factors identified in the development of disruptive behavior disorders. In: Murrihy, RC.; Kidman, AD.; Ollendick, TH., editors. Handbook of clinical assessment and treatment of conduct problems in youth. Springer; New York: 2010. p. 49-76.

Kochanska G. Toward a synthesis of parental socialization and child temperament in early development of conscience. Child Development. 1993; 64:325–347.

Kochanska G. Multiple pathways to conscience for children with different temperaments: from toddlerhood to age five. Developmental Psychology. 1997; 33:228–240. [PubMed: 9147832]

Kochanska G, Kim S. Toward a new understanding of legacy of early attachments for future antisocial trajectories: evidence from two longitudinal studies. Development and Psychopathology. 2012; 24:783–806. [PubMed: 22781855]

Kochanska G, Aksan N, Joy ME. Children's fearfulness as a moderator of parenting in early socialization: Two longitudinal studies. Developmental Psychology. 2007; 43:222–237. [PubMed: 17201521]

Kochanska G, Aksan N, Prisco TR, Adams EE. Mother-child and father-child mutually responsive orientation in the first two years and children's outcomes at preschool age: mechanisms of influence. Child Development. 2008; 79:30–44. [PubMed: 18269507]

Kochanska G, Philibert RA, Barry RA. Interplay of genes and early mother-child relationship in the development of self-regulation from toddler to preschool age. Journal of Child Psychology and Psychiatry. 2009; 50:1331–1338. [PubMed: 19207629]

Kochanska G, Kim S, Barry RA, Philibert RA. Children's genotypes interact with maternal responsive care in predicting children's competence: diathesis-stress or differential susceptibility? Development and Psychopathology. 2011; 23:605–616. [PubMed: 23786699]

Kochanska G, Boldt LJ, Kim S, Yoon JE, Philibert RA. Developmental interplay between children's biobehavioral risk and the parenting environment from toddler to early school age: prediction of socialization outcomes in preadolescence. Development and Psychopathology. 2014 doi: 10 .1017/S0954579414000777. Published online.

Lahey BB, Van Hulle CA, Keenan K, Rathouz PJ, D'Onofrio BM, Rodgers JL, Waldman ID. Temperament and parenting during the first year of life predict future child conduct problems. Journal of Abnormal Child Psychology. 2008; 36:1139–1158. [PubMed: 18568397]

Lansford JE, Deater-Deckard K, Dodge KA, Bates JE, Pettit GS. Ethnic differences in the link between physical discipline and later adolescent externalizing behaviors. Journal of Child Psychology and Psychiatry. 2004; 45:801–812. [PubMed: 15056311]

Lorber MF. Psychophysiology of aggression, psychopathy, and conduct problems: a meta-analysis. Psychological Bulletin. 2004; 130:531–552. [PubMed: 15250812]

Lykken DT. A study of anxiety in the sociopathic personality. Journal of Abnormal and Social Psychology. 1957; 55:6–10.

Lykken, DT. The antisocial personalities. Erlbaum; NJ: 1995.

Lytton H. Child and parent effects in boys' conduct disorder: a reinterpretation. Developmental Psychology. 1990; 26:683–697.

Mesman J, Stoel R, Bakermans-Kranenburg MJ, van IJzendoorn MH, Juffer F, Koot HM, Alink LRA. Predicting growth curves of early childhood externalizing problems: differential susceptibility of children with difficult temperament. Journal of Abnormal Child Psychology. 2009; 37:625–636. [PubMed: 19184403]

Nigg JT. Temperament and developmental psychopathology. Journal of Child Psychology and Psychiatry. 2006; 47:395–422. [PubMed: 16492265]

Parke RD, Buriel R. Damon W, Lerner RM, Eisenberg N. Socialization in the family: Ethnic and ecological perspectives. Handbook of child psychology: Social, emotional, and personality development. 2006:29–504.

Patterson, GR.; Reid, JB.; Dishion, TJ. Antisocial boys. Castalia; Eugene: 1992.

Posthumus JA, Bocker KBE, Raaijmakers MAJ, Van Engeland H, Matthys W. Heart rate and skin conductance in four-year-old children with aggressive behavior. Biological Psychology. 2009; 82:164–168. [PubMed: 19596046]

Preacher KJ, Curran PJ, Bauer DJ. Computational tools for probing interactions in multiple linear regression, multilevel modeling, and latent curve analysis. Journal of Educational and Behavioral Statistics. 2006; 31:437–448.

Raine A. Biosocial studies of antisocial and violent behavior in children and adults: a review. Journal of Abnormal Child Psychology. 2002; 30:311–326. [PubMed: 12108763]

Raine A. From genes to brain to antisocial behavior. Current Directions in Psychological Science. 2008; 17:323–328.

Raine A, Venables PH, Williams M. Relationships between central and autonomic measures of arousal at age 15 years and criminality at age 24 years. Archives of General Psychiatry. 1990; 47:1003–1007. [PubMed: 2241502]

Roisman GI, Newman DA, Fraley RC, Haltigan JD, Groh AM, Haydon KC. Distinguishing differential susceptibility from diathesis–stress: recommendations for evaluating interaction effects. Development and Psychopathology. 2012; 24:389–409. [PubMed: 22559121]

Rushton JP, Brainerd CJ, Pressley M. Behavioral development and construct validity: the principle of aggregation. Psychological Bulletin. 1983; 94:18–38.

Shaw DS, Owens EB, Vondra JI, Keenan K, Winslow EB. Early risk factors and pathways in the development of early disruptive behavior problems. Development and Psychopathology. 1996; 8:679–699.

Shaw DS, Gilliom M, Nagin DS, Ingoldsby EM. Trajectories leadin g to school-age conduct problems. Developmental Psychology. 2003; 39:189–200. [PubMed: 12661881]

Shojaei T, Wazana A, Pitrou I, Gilbert F, Bergeron L, Valla JP, et al. Psychometric properties of the Dominic interactive in a large french sample. Canadian Journal of Psychiatry. 2009; 54:767–776.

Sprafkin J, Gadow KD, Salisbury H, Schneider J, Loney . Further evidence of reliability and validity of the child symptom inventory-4: parent checklist in clinically referred boys. Journal of Clinical Child and Adolescent Psychology. 2002; 31:513–524. [PubMed: 12402570]

Valla, JP. The Dominic interactive: Instruction manual. D.I.M.A.T; Montreal: 2000.

Valla JP, Bergeron L, Bérubé H, Gaudet N, St-Georges M. A structured pictorial questionnaire to assess DSM-III-R-based diagnoses in children (6–11 years): development, validity, and reliability. Journal of Abnormal Psychology. 1994; 22:403–423.

Valla JP, Bergeron L, Smolla N. The Dominic-R: a pictorial interview for 6- to 11-year-old children. Journal of the American Academy of Child and Adolescent Psychiatry. 2000; 39:85–93. [PubMed: 10638071]

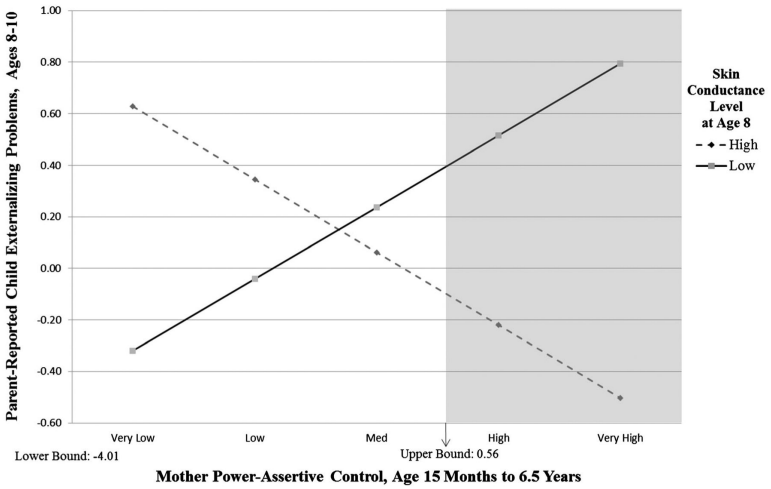

Fig. 1.

Children's skin conductance level moderates the effect of mothers' power-assertive control from 15 months to age 6 ½ on parent-reported child externalizing behavior problems at age 8–10. The solid line represents a significant simple slope, and the dashed line represents a non-significant simple slope. The shaded area represents the regions of significance. Child gender and mother and father education were covaried (not depicted).

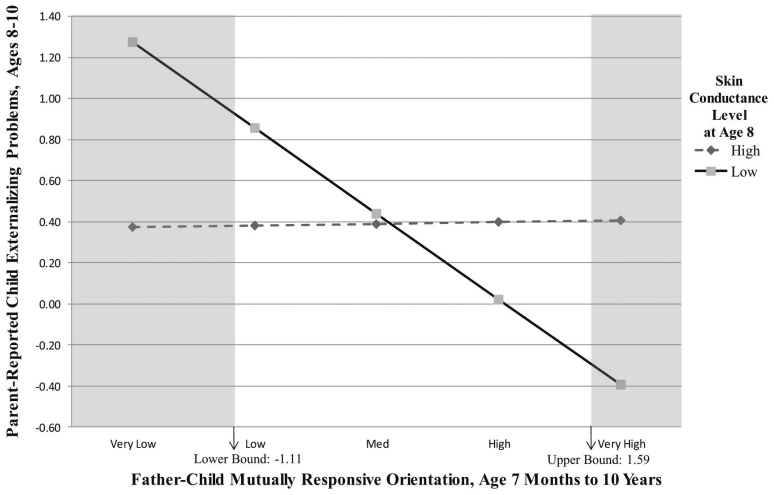

Fig. 2.

Children's skin conductance level moderates the effect of father-child MRO from 7 months to age 10 on parent-reported child externalizing behavior problems at age 8–10. The solid line represents a significant simple slope, and the dashed line represents a non-significant simple slope. The shaded areas represent the regions of significance. Child gender and mother and father education were covaried (not depicted).

Table 1

Descriptive data for the studied constructs

Construct	*M*	*SD*	Range	*N*
Predictors				
M-C MRO, 7 Months-Age 10	3.12	0.32	2.00–3.81	102
M-C Security, KSS, Age 8	52.10	5.66	30.00–60.00	86
M-C Security, KSS, Age 10	53.71	5.40	36.00–60.00	79
M-C Security, KSS, Age 8–10	53.02	4.37	36.00–60.00	86
M Power-Assertion, 15 Months-Age 6 ½[a]	0.00	1.00	−1.51–4.13	101
F-C MRO, 7 Months-Age 10	3.01	0.31	1.90–3.68	102
F-C Security, KSS, Age 8	50.58	6.16	35.00–60.00	84
F-C Security, KSS, Age 10	53.78	5.25	32.00–60.00	78
F-C Security, KSS, Age 8–10	52.29	4.59	34.00–60.00	85
F Power-Assertion, 15 Months-Age 6 ½[a]	0.00	1.00	−1.82–3.89	101
Moderator, Age 8				
Skin Conductance Level[a]	0.00	1.00	−2.07–2.02	74
Outcomes, Age 8				
C Externalizing Score (CSI-4, M-Rated)	6.67	4.25	0.00–28.00	86
C Aggression (HBQ, M-Rated)	1.24	0.26	1.00–2.00	86
C Externalizing Score (CSI-4, F-Rated)	6.26	3.68	0.00–16.00	82
C Aggression (HBQ, F-Rated)	1.21	0.24	1.00–2.00	82
C Externalizing (M/F-Rated)[a]	0.02	0.80	−1.16–3.40	87
C Externalizing (Dominic-R, C-Rated)	8.81	7.70	0.00–41.00	86
Outcomes, Age 10				
C Externalizing Score (CSI-4, M-Rated)	6.73	4.31	0.00–21.00	81
C Aggression (HBQ, M-Rated)	1.24	0.25	1.00–2.25	81
C Externalizing Score (CSI-4, F-Rated)	6.17	4.24	0.00–19.00	78
C Aggression (HBQ, F-Rated)	1.22	0.25	1.00–2.25	78
C Externalizing (M/F-Rated) [a]	0.02	0.85	−1.22–3.52	82
C Externalizing (Dominic-R, C-Rated)	6.35	5.92	0.00–28.00	79
Outcomes, Age 8-10				
C Externalizing (M/F-Rated)[a]	0.02	0.78	−1.16–3.46	87
C Externalizing (Dominic-R, C-Rated)	7.72	5.78	0.00–29.00	86

M Mother, *F* Father, *C* Child, *MRO* Mutually Responsive Orientation, *KSS* Kerns Security Scale, *CSI–4* Child Symptom Inventory–4, *HBQ* Health Behavior Questionnaire

[a] A composite of standardized constituent variables

Table 2

Relations between the predictors (parent–child MRO, 7 months to age 10, security, age 8 to 10, parental power-assertive control, 15 months to age 6 ½) and child skin conductance level (age 8) and externalizing behavior problems at age 8–10

	C Externalizing Problems, Age 8–10					
	M/F-Rated			Self-Reported		
	All	Low SCL	High SCL	All	Low SCL	High SCL
M-C MRO, 7 Months-Age 10	−0.38****	−0.48***	−0.10	−0.26**	−0.31+	−0.12
M-C Security, Age 8-10	−0.06	−0.12	0.11	−0.34****	−0.38**	−0.33*
M Power Assertion						
15 Months-Age 6 ½	0.43****	**0.53** ****	**0.02**	0.38****	0.53****	−0.03
F-C MRO, 7 Months-Age 10	−0.35****	− **0.57** ****	− **0.10**	−0.17	−0.32+	0.08
F-C Security, Age 8-10	−0.05	−0.19	0.23	−0.40****	−0.54****	−0.25
F Power Assertion						
15 Months-Age 6 ½	0.36****	0.40**	0.23	0.44****	0.42***	0.35*
Skin Conductance Level, Age 8	−0.15	–	–	−0.17	–	–

M Mother, *F* Father, *C* Child, *SCL* Skin Conductance Level, *Low SCL* Below the median, *High SCL* Above the median. The bolded figures correspond to the significant interaction effects in regression analyses

+ $p<0.10$.

* $p<0.05$.

** $p<0.025$.

*** $p<0.01$.

**** $p<0.001$.

Table 3

Parent–child MRO (7 months to age 10), security (age 8 to 10), and parental power assertion (15 months to age 6 ½) and child skin conductance level (age 8) as predictors of externalizing behavior problems at age 8–10

Relationship:	**Outcome Measures: Children's Externalizing Problems, Age 8–10**							
	M/F-Rated				**Self-Reported**			
	Mother-Child		**Father-Child**		**Father-Child**		**Father-Child**	
	Beta	***F***	***Beta***	***F***	***Beta***	***F***	***Beta***	***F***
Child Gender	0.25	4.49*	0.08	<1	0.03	<1	0.09	<1
Mother Education	0.02	<1	−0.06	<1	−0.07	<1	−0.12	1.26
Father Education	−0.16	2.03	−0.14	1.51	0.12	1.12	0.12	1.07
MRO	−0.14	<1	−0.55	9.61***	0.13	<1	0.09	<1
Security	−0.02	<1	0.01	<1	−0.28	2.91+	−0.53	12.50****
Power Assertion	0.35	4.52*	0.15	1.05	0.51	9.84***	0.33	5.16*
SCL	−0.10	<1	−0.02	<1	−0.13	1.34	−0.03	<1
MRO × SCL	−0.10	<1	0.37	5.69**	0.00	<1	0.04	<1
Security × SCL	0.25	1.78	0.13	<1	−0.07	<1	0.16	1.24
Power × SCL	−0.31	4.59*	0.05	<1	−0.16	1.24	0.07	<1
	R^2=0.34		R^2=0.38		R^2=0.34		R^2=0.39	
	$F(10,62)=3.18^{***}$		$F(10,61)=3.73^{***}$		$F(10,62)=3.20^{***}$		$F(10,61)=3.84^{****}$	

SCL Skin Conductance Level. For all equations, the final step, with all predictors entered, is presented. *MRO*, security, and power assertion are for the given parent–child relationship

+ $p<0.10$.

* $p<0.05$.

** $p<0.025$.

*** $p<0.01$.

**** $p<0.001$.