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Early regulatory problems and parenting: life-long risk, vulnerability or susceptibility for attention, internalizing and externalizing outcomes?

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Declarations

Funding: This study was supported by grants PKE24, JUG14, 01EP9504 and 01ER0801 from the German Federal Ministry of Education and Science (BMBF), and the analyses by grant DFG SCHM 3045/2-1 from the German Research Foundation (DFG).

Conflicts of Interest: None.

Availability of data and material: Aggregate data will be made available by authors upon request.

Code availability: Not applicable.

Acknowledgements: We would like to thank all current and former Bavarian Longitudinal Study group members, paediatricians, psychologists, and research nurses. Special thanks are due to the study participants and their families.

Word count: 3078

Keywords: regulatory problems, parenting, life-course, confirmatory-comparative modelling, attention regulation, CBCL, YASR

Abstract

Multiple or persistent crying, sleeping, or feeding problems in early childhood (regulatory problems, RPs) predict increased risk for self-regulation difficulties. Sensitive parenting may protect children from trajectories of dysregulation. Considering self-regulation from a life-course perspective, are children with early multiple and/or persistent RPs affected similarly by parenting as those without (main effects model, ME), or are they more vulnerable (diathesis-stress, DIA-S), or more susceptible (differential susceptibility theory, DST) to variations in sensitive parenting at age six years? Participants (*N*= 302) were studied prospectively from birth to 28 years. RPs were assessed from five to 56 months. Sensitive parenting was observed at six years. Attention regulation was observed at eight and 28 years. Internalizing and externalizing problems were rated by parents at eight, and by adults at 28 years. Confirmatory-comparative modelling tested whether associations of sensitive parenting with outcomes at 8 and 28 years among individuals with early multiple and/or persistent RPs (*n*=74) versus those without (*n*=228) were best explained by ME, DIA-S, or DST models. Best fitting models differed according to age at assessment. For childhood attention regulation, the statistically parsimonious DIA-S provided the best fit to the data. At age 28, two additive main effects (ME, RP group and sensitive parenting) fit best. DIA-S and ME explained internalizing and externalizing problems. Using a comprehensive life-span approach, DIA-S and ME models but not DST explained how early RPs and sensitive parenting predicted attention, internalizing, and externalizing outcomes. Individuals with early RPs are vulnerable to insensitive parenting.

Crying, feeding, and sleeping are fundamental for infants' survival and development (Berger, Kofman, Livneh, & Henik, 2007). Failure in learning to self-regulate these behaviours may result in excessive crying, feeding or sleeping problems such as difficulties with self-soothing, overcoming neophobia to new food, or settling back to sleep at night (Olsen, Ammitzbøll, Olsen, & Skovgaard, 2019; Popp et al., 2016). Crying, feeding and sleeping problems may cause serious concerns for parents and involve significant health service use (Hemmi, Wolke, & Schneider, 2011; James-Roberts, Alvarez, & Hovish, 2013). While most early regulatory problems (RPs) are transient, multiple RPs in infancy or persistent RPs into toddlerhood have been associated with an increased risk for long-term attention and behaviour regulation difficulties (Baumann et al., 2019; Bilgin et al., 2018; Jusiene, Breidokiene, & Pakalniskiene, 2015; Winsper & Wolke, 2013).

Self-regulation is a broad and multifaceted construct including bodily and behavioural-cognitive functions. While dyadic co-regulation of state control is critically important during the first months of life (Ludwig & Welch, 2019; Papoušek, 2011), self-control at later ages involves continually changing developing dimensions such as inhibition (Jaekel, Eryigit-Madzwamuse, & Wolke, 2016), delay of gratification (Mischel et al., 2011), executive attention (Rothbart, Sheese, Rueda, & Posner, 2011), and theory of mind (Keller, 2002). In addition, early temperamental characteristics contribute to children's self-regulatory abilities (Gartstein, Putnam, & Rothbart, 2012). Behavioural, emotional, and attention regulation, in particular, are highly relevant for individuals' academic achievement and life-course success (Blair & Raver, 2015; Moffitt et al., 2011). Given this critical importance, a large body of research has focused on identifying environmental factors such as parenting that may help children improve their self-regulatory skills. Maternal sensitivity, defined as adaptive, prompt, and responsive parenting that allows dyadic co-regulation of behaviour (Jaekel, Wolke, & Chernova, 2012a; Li, 2003) is associated with positive developmental outcomes, and may protect children from trajectories of dysregulation (Breeman et al., 2018). Alternatively, considering the dyadic nature of parent-child interaction in the context of early RPs, distressed parents may develop suboptimal parent-infant relationships due to lack of sleep, insecurity about their parenting, and frustration with the child (Papousek & von Hofacker, 1998; Richter, Kramer, Tang, Montgomery-Downs, & Lemola, 2019). This may in turn aggravate childhood attention and behavioural problems.

Assessing strategies that can help reduce potential long-term consequences of early RPs is critical. Stopping crying, falling back to sleep, and overcoming neophobia are among the first normative regulatory tasks in infancy but it is unknown how RPs and sensitive parenting may influence attention regulation, internalizing and externalizing behaviour across time into adulthood. First, early RPs and sensitive parenting may have independent associations with attention and behavioural development; i.e. additive main effects (ME Model, Fig 1a). Alternatively, sensitive parenting may buffer against the negative effect of early RPs on later outcomes as predicted by the diathesis-stress model (DIA-S) (Zuckerman, 1999). According to DIA-S, individuals with early RPs are more vulnerable and their developmental outcome is worse than their peers under adverse environmental conditions (e.g., low sensitive parenting), but they catch-up to levels of those without RPs when reared under favourable conditions (e.g., highly sensitive parenting). This is indicated by a statistical interaction effect (Fig 1b). Finally, according to Differential Susceptibility Theory (DST), RPs are considered a marker for heightened reactivity to environmental exposures and increased developmental plasticity (Belsky, Hsieh, & Crnic, 1998; Belsky & Pluess, 2016; Slagt, Dubas, Deković, & van Aken, 2016). DST predictions are that those with early RPs will do worse than their peers given an adverse environment (e.g., low sensitive parenting). The difference to DIA-S is that DST predicts better than average performance of individuals with early RPs given an enriched environment (e.g., highly sensitive parenting) (statistical interaction effect; Fig 1c). In contrast, those without the risk factor are assumed to be invulnerable and thus less affected by adverse or enriched environments.

- Fig 1 about here -

In the current study, we addressed the following question: Considering self-regulation from a life-course perspective, are children with multiple and/or persistent RPs in early childhood affected similarly by low or high maternal sensitivity as those without multiple and/or persistent RPs (ME), or are they more vulnerable (DIA-S), or more susceptible (DST) to differences in sensitive parenting at age 6 years?

METHODS

Sample

The Bavarian Longitudinal Study (BLS) is a prospective geographically defined whole population sample of neonatal at-risk and healthy comparison children born between January 1985 and March 1986 in Southern Bavaria (Germany). The present study utilizes data collected from birth to adulthood (Bilgin et al., 2018). Of 708 eligible childhood participants, 320 were selected for adult follow-up. Of these, 302 individuals were assessed (mean age 27.6 (SD=1.8) years, Figure S1).

Measures

Multiple and/or persistent regulatory problems. Standardized parent interviews concerning crying, feeding, and sleeping problems were conducted by trained paediatricians at 5 months of infant age. At 20 and 56 months, sleeping and eating problems were again assessed via parent interviews, and neurological examinations of oral motor function conducted by paediatricians (Bilgin et al., 2018; Schmid & Wolke, 2014). Paediatricians were trained to achieve > 90% inter-rater reliability and received three monthly booster workshops throughout data collection. Assessments at 5 and 20 months were carried out corrected for prematurity, assessments at 56 months according to chronological age. Definitions of crying, feeding, and sleeping problems were derived from previous studies (St James-Roberts & Halil, 1991; St James-Roberts & Peachey, 2011). Further, the variable coding for this study was based on previous meta-analytic evidence showing that particularly children with multiple and/or persistent RPs during infancy had an increased risk of behaviour problems in childhood (dose-response relationship) (Hemmi et al., 2011). Children were classified as having multiple RPs if they had at least two of the following problems at 5 months: *a crying problem* (cry duration ≥2 hours/day, cry amount above average, soothing difficult), *a sleeping problem* (often or long night waking), or *a feeding problem* (drinking, vomiting, flatulence, or bowel (gastrointestinal) problems). Persistent RPs were defined as having at least one problem at 5, 20, and 56 months of age (Bilgin et al., 2018; Schmid & Wolke, 2014). Multiple and/or persistent RPs were combined into one binary variable (0 = never RPs, 1 = multiple and/or persistent RPs).

Maternal sensitivity. At age six, maternal sensitivity was observed and rated during a structured dyadic cooperation task using an established standardized coding system, the "Assessment of Mother-Child-Interaction with an Etch-a-Sketch" (AMCIES) (Jaekel, Wolke, & Chernova, 2012b; Wolke, Rios, & Unzer, 1995). Raters (psychologists) received extensive training, bimonthly feedback, and frequent refreshers, establishing >90% continuous rating agreement across nine observers. Rating scales consisted of three continuous subscales for the mother (Verbal Control, Non-Verbal Control, and Criticism, all reverse-coded) and one subscale for mother-child joint behaviour (Harmony) (Jaekel, Pluess, Belsky, & Wolke, 2015; Wolke, Jaekel, Hall, & Baumann, 2013) that were z-standardized and combined into a comprehensive index of Maternal Sensitivity, reflecting an ecologically valid, continuously scaled, multidimensional construct. The AMCIES coding system has established high inter-rater reliabilities and in-vivo rated scores show excellent convergence with video-rated scores of Maternal Sensitivity (Wolke et al., 2013) (intraclass-correlation coefficient of 0.76, $p<.001$, for two master raters in a large childhood sample of n=565).

Observer-rated attention regulation. At age 8 and 28 years, attention regulation skills were assessed during cognitive tasks using the standardized Tester's Rating of Child Behaviour (TRCB) (Jaekel, Wolke, & Bartmann, 2013) and Tester's Rating of Adult Behaviour (TRAB) (Breeman, Jaekel, Baumann, Bartmann, & Wolke, 2016), respectively. Trained psychologists scored participants' attention on dimensional scales from 1 (very low) to 9 (very high). In addition, attention across the whole assessment day was evaluated as a consensus rating by the whole research team at 8 years, and by the interviewing psychologist at 28 years, on the same nine-dimensional scales. The observer-rated attention index score was formed by averaging the testers' and teams' scores for each participant at each time point (*r*>0.80, reflecting high internal consistency and ecological validity), with higher scores indicating better attention regulation.

Internalizing & externalizing behaviour problems. At age 8 years, parents rated their children's behavioural and emotional problems with the Child Behavior Checklist (CBCL) (Achenbach, 1991). At 28 years, adult participants rated their own behavioural and emotional problems with the Young Adult Self Report (YASR) (Achenbach, 1997). Each time, items were rated on a scale from 0 (not true) to 2 (very/often true) and raw scores were summed into established total scores for internalizing and externalizing behaviour, with higher scores indicating more problems.

Descriptive sample characteristics. Gestational age was determined from maternal reports of the last menstrual period and serial ultrasounds during pregnancy; birth weight and child sex were coded from medical records at birth. Family socioeconomic status (SES) at birth was computed as a weighted composite score of parents' education and occupation ranging from 1 (lowest) to 6 (highest) (Bauer, 1988).

Analytic Approach

Analyses were conducted using SPSS 23. Maternal sensitivity and all dependent variables were *z*-standardized, thus reported unstandardized regression coefficients can be interpreted as standardized betas. First, separately for each dependent variable, ME models were run to identify the two simple additive contributions of multiple/persistent RPs and maternal sensitivity (Model 1). Second, confirmatory-comparative modelling was performed to test whether individuals with multiple/persistent RPs (*n*=74) were more susceptible (DST, Models 2a+b), rather than just more vulnerable (DIA-S, Models 3a+b) to variations in sensitive parenting than their peers without multiple/persistent RPs (*n*=228) (Widaman et al., 2012).

Both DST and DIA-S models predict that a below average environment (i.e., low maternal sensitivity) will result in less optimal outcomes for individuals with multiple/persistent RPs compared with their peers. However, DST predicts that an above average environment (i.e., high sensitivity) will result in significantly better outcomes for individuals who had multiple/persistent RPs compared to their peers who received similarly high levels of sensitivity in childhood. In contrast, DIA-S predicts that an above average environment will be associated with equal outcomes across both groups (i.e., catch-up). In addition, each theoretical model has a strong and a weak version: Strong DST (Model 2a) and strong DIA-S (Model 3a) predict that children without multiple/persistent RPs are unaffected by the environment (i.e., their regression line slope is set to zero). In contrast, weak DST (Model 2b) and weak DIA-S (Model 3b) predict that children without multiple/persistent RPs are influenced by the environment but to a lesser degree than those with multiple/persistent RPs (i.e., slopes are freely estimated). Finally, results of Models 1-3b were compared for each dependent variable separately to determine which model provided the best fit to the data, considering the corrected Akaike information criterion (*AIC*), Bayesian information criterion (*BIC*), amount of explained variance (R^2), and statistical parsimony.

Results

Table 1 shows descriptive sample characteristics, comparing individuals who had multiple/persistent RPs in early childhood with those who did not. Based on two-tailed t- and

χ^2- tests, there were no between-group differences with regard to gestational age, birth weight, sex, SES at birth, maternal sensitivity at age 6, and observer-rated attention at age 8 years. On average, individuals with multiple/persistent RPs had higher externalizing and internalizing problems at age 8 and 28 years, and lower observer-rated attention scores at age 28 than those without RPs.

- Table 1 about here -

Results for the comparative regression models 1-3b on attention outcomes are presented in Table S1 and Fig 2 a+b. Overall, maternal sensitivity and multiple/persistent RPs had stable significant effects. The weak DIA-S model provided the best fit to the data at age 8 (Model 3b, *AIC*= -77.880; R^2=.12), i.e., children with multiple/persistent RPs were more vulnerable to insensitive parenting than their peers without RPs, and they had similar attention scores compared to non RP peers when they experienced highly sensitive parenting. When interpreting Fig 2a, please note that fit values and explained variation of the weak DST model were comparable (Model 2b, *AIC*= -77.163; R^2=.13, *F(*3d vs. 3b)=1.33, *p*=.249) to the weak DIA-S model, however, the weak DIA-S model was statistically more parsimonious and thus considered a better fit. At age 28 years, the parsimonious ME model provided the best fit (Model 1, *AIC* = -8.350, R^2=.05), i.e., both early multiple/persistent RPs and sensitive parenting at age 6 made additive contributions to attention regulation at age 28. Statistical fit for the strong DST model (indicating, unexpectedly, high susceptibility of individuals without RPs) was good, but the crossover point was close to being outside of the range of actual data thus refuting the fit of DST (Roisman et al., 2012), see Fig 2b.

- Fig 2 about here -

With regard to internalizing behaviour problems, statistically, the ME model provided the best fit at age 8 (see Table S2, Model 1, *AIC* = 7.348, R^2=.05), while the weak DIA-S provided the best fit to the data at age 28 (Model 3b, *AIC* = -7.054, R^2=.06). Please see Figures 2 c+d, depicting the direction of associations on this problem-scale outcome (i.e., higher values on the y-axis indicate higher problems).

For externalizing behaviour problems, Table S3 shows that the ME Model provided the best fit to the data at both 8 and 28 years. Accordingly, Figures 2 e+f suggest two additive main effects rather than an interaction, i.e., RPs and variations in maternal sensitivity both independently contributed to explain externalizing problems (higher y-axis values indicate higher problems). Table 2 provides on overview of the competitive model testing results.

- Table 2 about here -

Discussion

This study tested the fit of three alternative theoretical models (ME, DST, DIA-S) to evaluate how variations in sensitive parenting predict later outcomes among individuals with and without early multiple/persistent RPs. We employed a statistically rigorous life-span approach to assess developmental outcomes across three dimensions (attention regulation, internalizing, and externalizing problems). In summary, participants who had had early RPs were affected to the same extent by variations in sensitivity at age 6 as those without early RPs with regard to internalizing and externalizing problems at school-age and attention regulation and externalizing problems in adulthood (see Table 2). High maternal sensitivity predicted better outcomes, while having multiple/persistent RPs predicted less optimal outcomes. In addition, individuals with early RPs were more vulnerable to insensitive parenting with regard to attention regulation at age 8 and internalizing behaviours at age 28 years than individuals without early RPs.

In line with our current findings, other studies have documented that early RPs and parenting may act as additive or interactive risks for later outcomes. A study of RPs and parenting in the first 5 months found that after correction for gestational age, sex, and socioeconomic status, both early RPs and low parenting quality predicted childhood attention problems (Breeman et al., 2018). Their impact was additive, such that children with both multiple/persistent RPs and poor parenting quality in early infancy showed the highest attention problems 8 years later. Another study of bi-directional relationships between responsive parenting and infants' negative emotionality on behaviour problems of children with difficult temperaments suggested that DIA-S provided good fit, but DST did not (Kochanska & Kim, 2013). However, a meta-analytical study suggested that parenting-by-temperament interactions may be following the DST model in infancy but turn into DIA-S later in childhood (Slagt et al., 2016).

Given that resources to provide interventions for children growing up with developmental risks are usually limited, identifying individuals who are at long-term risk and may benefit from interventions is critically important. According to the results of our competitive model testing, individuals with multiple/persistent RPs in early childhood are at risk for adverse long-term outcomes and vulnerable to low-quality parenting. This indicates that multiple/persistent early RPs are not a normal variation of a behavioural profile such as temperament or personality that may make children highly susceptible for-better-or-worse. Indeed, a recent study suggests that the central nervous system of newborns developing infant colic shows higher reactivity to sensory stimuli than that of their non-colicky peers (Adam-Darque et al., 2020). What's more, this early sensitivity explained 48% of infants' later crying behaviour, and brain activation patterns were wide-spread, including neural regions usually involved in pain processing, emotional valence attribution, and self-regulation (Adam-Darque et al., 2020). Accordingly, there is increasing evidence that multiple/persistent early RPs indicate a mental health risk that may benefit from intervention (Cook et al., 2019; Winsper, Bilgin, & Wolke, 2019), and children with early RPs may particularly benefit from interventions that facilitate highly sensitive parenting. In infancy, cry and sleep interventions have shown short-term positive outcomes (Hiscock et al., 2007; Wolke, Gray, & Meyer, 1994) and are well accepted by parents without harmful side effects (Honaker, Schwichtenberg, Kreps, & Mindell, 2018; Price, Wake, Ukoumunne, & Hiscock, 2012; Wolke, 2019). However, studies documenting long-term benefits of interventions for children with early RPs are scarce. The current results suggest that increasing sensitive parenting may be a promising target for interventions to reduce the risk for lifelong sequelae of early RPs.

This study has several strengths, including the prospective design from infancy to adulthood, multiple measures and data sources including standardized observations in a large sample of individuals who had multiple/persistent RPs and controls, and rigorous theory-driven hypothesis testing. We intentionally investigated externalizing and internalizing behavior problems as separate dimensions, as studies have shown that they mark and predict different developmental profiles across childhood and the life-course (Caspi et al., 2014; Pettersson, Anckarsater, Gillberg, & Lichtenstein, 2013; Winsper et al., 2019; Winsper & Wolke, 2013). Therefore, we aimed to uncover potentially different mechanisms related to the different outcome dimensions when applying the comparative model testing. There are also limitations. First, RPs were assessed as clinical diagnoses and coded as a binary variable (multiple and/or persistent RPs, yes vs. no) and not along a continuum. While this may limit application of findings to the whole population it represents a theoretically and clinically meaningful approach. Second, the sample of this study included some individuals born preterm. However, Table 1 shows that gestation and birth weight were in the normal range and equally distributed across both groups, we controlled for gestational age in all analyses, and the actual differences in rates of RPs between even very preterm and full term infants have been found to be small (Bilgin & Wolke, 2016). We are confident that the adult participants compared here are not of significantly higher neonatal risk than expected from a typical normal population sample. In addition, the effect of gestational age on adult outcomes was non-significant across all models we tested (B = -.04 to .05, see Tables S1-3). Third, maternal sensitivity was assessed at age 6 years and not in infancy. In this life-course follow-study, observational ratings of parenting behaviour were not available at younger ages, however, we would argue that maternal sensitivity is highly stable throughout childhood and dyadic variations in sensitivity at child age 6 years likely reflect individual differences that were at play from infancy. None of the children in this sample had any changes in major caregivers, all sensitivity observations were administered to biological mother-child dyads. Within this homogeneous group, however, substantial variations in the degree of maternal sensitivity at age 6 years were found, with ratings below -1 standard deviation indicating environmental adversity in the form of insensitive parenting.

Conclusion. Most of the evidence presented here suggests that children with multiple and/or persistent early RPs are affected similarly by variations in maternal sensitivity as their peers without RPs. Some evidence was found for diathesis-stress theory, i.e., individuals with early RPs may be vulnerable to insensitive parenting, in particular with regard to childhood attention regulation and adult internalizing problems. Early identification and development of interventions in primary care may help reduce the long term adverse mental health consequences of multiple/persistent early RPs. While parenting interventions around preschool age may help prevent life-course attention and internalizing problems, all children benefit from high levels of maternal sensitivity in order to prevent detrimental outcomes, irrespective of early RPs.

Ethical standards

Ethical approval for the study was granted by the ethics committees of the University of Munich Children's Hospital, the Bavarian Health Council (Landesärztekammer Bayern), and the University Hospital Bonn, the study was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Informed consent was obtained from parents (infancy and childhood) and participants (adulthood) prior to their inclusion in each assessment.

Conflict of interest

The authors declare that they have no conflict of interest.

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Table 1. Descriptive sample characteristics comparing individuals with versus without multiple/persistent early RPs

	Multiple/persistent RPs		**Never RPs**		***p*-value**
Gestational age at birth (weeks)	*n*=74	37.08 (4.08)	*n*=228	36.79 (4.16)	.599
Birth weight (grams)	*n*=74	2703 (903)	*n*=228	2705 (957)	.984
Sex (% male)	*n*=74	48.6%	*n*=228	51.3%	.789
SES at birth	*n*=74	3.30 (1.49)	*n*=228	3.17 (1.52)	.518
Maternal sensitivity at 6 years (z-score)	*n*=73	0.10 (0.59)	*n*=228	0.10 (0.64)	.926
Outcomes at age 8 years (z-scores)					
Observer-rated attention	*n*=73	-0.12 (1.13)	*n*=221	0.04 (0.85)	.186
Externalizing problems (CBCL)	*n*=73	0.21 (1.00)	*n*=222	-0.07 (0.96)	.028
Internalizing problems (CBCL)	*n*=73	0.34 (1.14)	*n*=222	-0.07 (0.97)	.007
Outcomes at age 28 years (z-scores)					
Observer-rated attention	*n*=74	-0.31 (1.05)	*n*=228	0.10 (0.96)	.004
Externalizing problems (YASR)	*n*=74	0.23 (1.02)	*n*=228	-0.04 (1.01)	.048
Internalizing problems (YASR)	*n*=74	0.28 (1.09)	*n*=228	-0.07 (0.97)	.010

Data are reported as mean (SD) if not stated otherwise.

Table 2. Summary of comparative model testing results of the two effects of early multiple/persistent RPs and sensitive parenting at age 6 on long-term outcomes

	Main Effects (ME)	**Diathesis-Stress (DIA-S)**	**Differential Susceptibility (DST)**
Attention 8 years	-	✓	-
Attention 28 years	✓	-	-
Internalizing 8 years	✓	-	-
Internalizing 28 years	-	✓	-
Externalizing 8 years	✓	-	-
Externalizing 28 years	✓	-	-

Please note: Checkmarks indicate which model provided the best fit to the data.

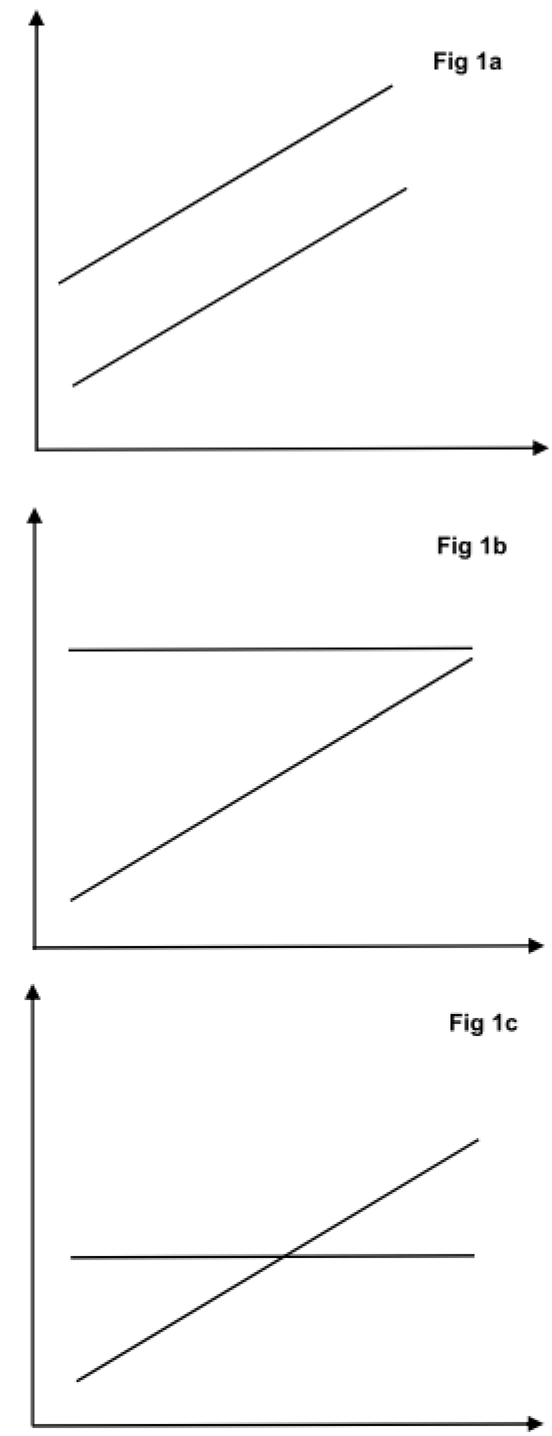

Figure 1 a-c. Prototypical Main Effects (a), Dual Risk (b), and Differential Susceptibility (c) plots. Higher values on the X and Y axes indicate more positive environmental inputs and developmental outcomes, respectively.

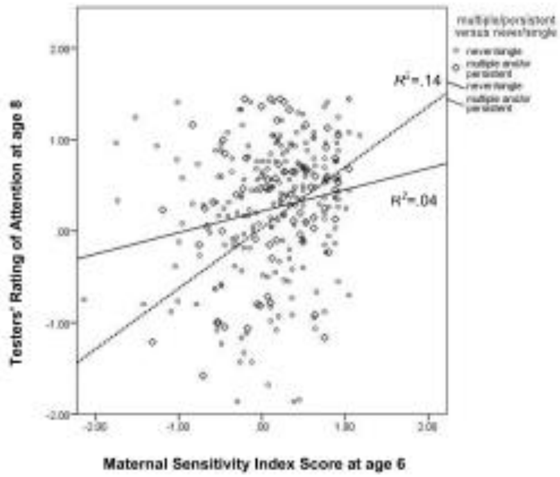

Fig 2a; DIA-S

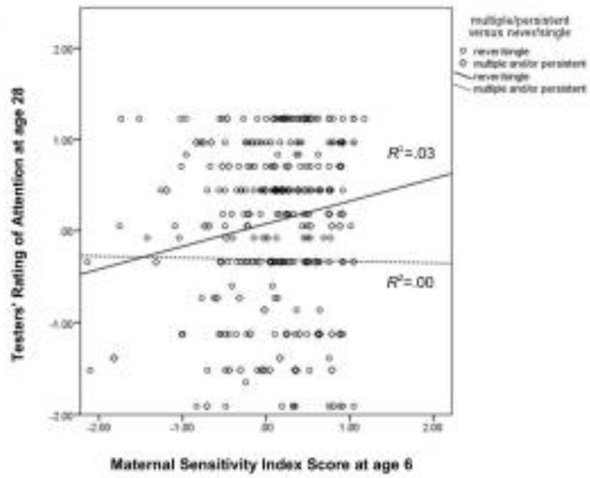

Fig 2b; ME

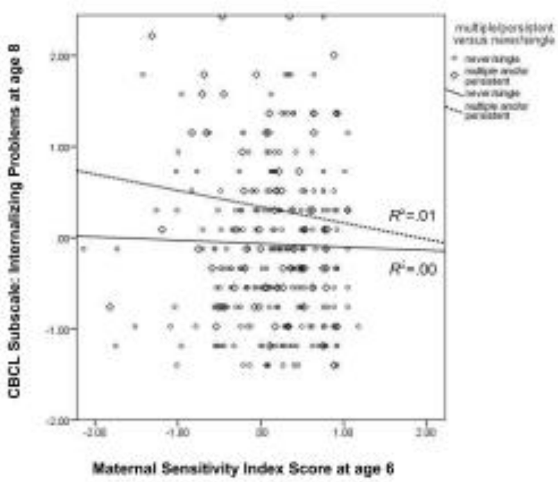

Fig 2c; ME

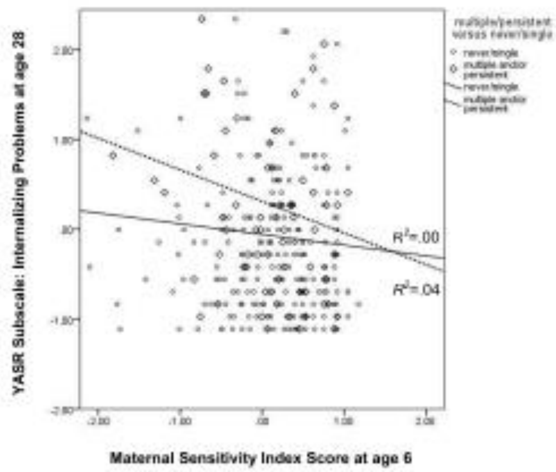

Fig 2d; DIA-S

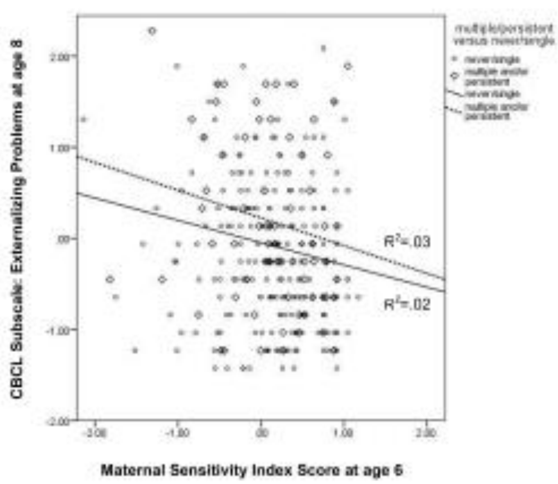

Fig 2e; ME

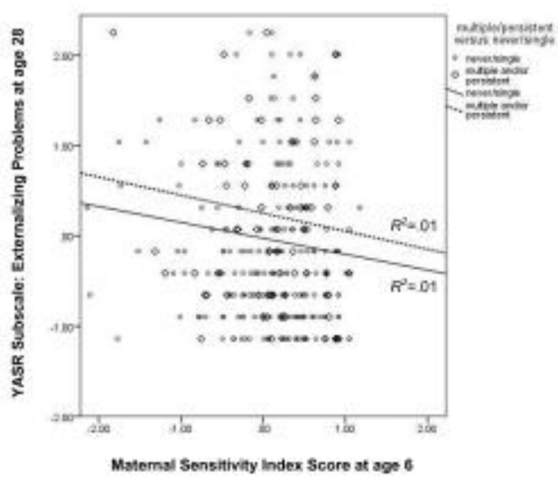

Fig 2f; ME

Figure 2 a-f. Effects of sensitive parenting on multiple/persistent RP versus non-RP individuals' attention regulation, internalizing, and externalizing behaviour at age 8 and 28 years.

Please note: Raw data is shown here, while the main models were adjusted for GA at birth; R^2 indicates the size of the simple linear effect within each group; ME = the main effects model provided the best fit; DIA-S = the diathesis stress model provided the best fit to the data.

Supplementary Materials

Table S1. Comparison of alternate regression models testing effects of maternal sensitivity at age 6 years on RP versus non-RP individuals' attention regulation at 8 and 28 years

			Reparametrized regression equations			
	Main effects (ME)		**Differential Susceptibility (DST)**		**Diathesis-Stress (DIA-S)**	
			Strong:	Weak:	Strong:	Weak:
8 years	Model 1		Model 2a	Model 2b	Model 3a	Model 3b
B_0 (Intercept)	**-1.68 (.48)**	**B_0**	**-2.05 (.48)**	**-1.63 (.47)**	**-1.85 (.48)**	**-1.44 (.47)**
B_1 (sensitivity)	**.35 (.09)**	**B_1**	.00 (-)	**.67 (.18)**	.00 (-)	**.51 (.11)**
B_2 (RP group)	-.16 (.12)	**C**	-.54 (.54)	.50 (.34)	1.18 (-)	1.18 (-)
B_3 (interaction)	--	**B_3**	**.25 (.10)**	**.25 (.10)**	.08 (.08)	**.30 (.09)**
R^2	.11	***R^2***	.08	.13	.06	.12
	--	***F vs. 2b***	14.25	--	10.96	1.33
	--	***df***	289	--	289	289
	--	***p***	<.001	--	<.001	.249
	--	***F vs. 3a***	7.32	10.96	--	20.56
	--	***df***	290	289	--	290
	--	***p***	.007	<.001	--	<.001
AIC (corrected)	-74.884	***AIC***	-65.079	-77.163	-59.802	-77.880
BIC	-72.913	***BIC***	-63.107	-75.200	-57.823	-75.908
28 years	Model 1		Model 2a	Model 2b	Model 3a	Model 3b
B_0 (Intercept)	**1.22 (.53)**	**B_0**	.38 (.52)	.37 (.60)	.74 (.53)	1.01 (.53)
B_1 (sensitivity)	**.20 (.09)**	**B_1**	.00 (-)	.00 (.20)	.00 (-)	**.38 (.13)**
B_2 (RP group)	**-.41 (.13)**	**C**	-1.56 (.86)	-1.58 (1.62)	1.18 (-)	1.18 (-)
B_3 (interaction)	--	**B_3**	**.25 (.10)**	**.25 (.10)**	-.01 (.08)	.15 (.09)
R^2	.05	***R^2***	.06	.06	.01	.04
	--	***F vs. 2b***	.00	--	7.76	6.09
	--	***df***	297	--	297	297
	--	***p***	1.000	--	<.001	.014
	--	***F vs. 3a***	15.57	7.76	--	9.28
	--	***df***	298	297	--	298
	--	***p***	<.001	<.001	--	.003
AIC (corrected)	-8.350	***AIC***	-9.581	-7.513	-3.748	-3.455
BIC	-6.378	***BIC***	-7.609	-5.548	5.727	-1.483

Please note: AIC, Akaike information criterion; BIC, Bayesian information criterion. Significant parameters are marked bold. F versus 2b/3a stands for an F test of the difference in R2 for a given Model versus Model 2b/3a. All models are controlled for gestational age at birth (B = -.04 to .05).

Table S2. Comparison of alternate regression models testing effects of maternal sensitivity at age 6 years on RP versus non-RP individuals' internalizing behaviour problems at 8 and 28 years

			Reparametrized regression equations			
	Main effects (ME)		**Differential Susceptibility (DST)**		**Diathesis-Stress (DIA-S)**	
			Strong:	Weak:	Strong:	Weak:
8 years (CBCL)	Model 1		Model 2a	Model 2b	Model 3a	Model 3b
B_0 (Intercept)	.73 (.55)	**B_0**	**1.54 (.54)**	1.00 (.82)	**1.33 (.54)**	**1.09 (.55)**
B_1 (sensitivity)	-.06 (1.00)	**B_1**	.00 (-)	-.14 (21)	.00 (-)	**-.30 (13)**
B_2 (RP group)	**.40 (.14)**	**C**	-11.76 (39.36)	4.03 (9.12)	1.18 (-)	1.18 (-)
B_3 (interaction)	--	**B_3**	-.03 (.11)	-.03 (.11)	.14 (.08)	.01 (.10)
R^2	.05	***R^2***	.05	.05	.03	.04
	--	***F vs. 2b***	1.42	--	3.11	1.04
	--	***df***	290	--	290	290
	--	***p***	.235	--	.046	.308
	--	***F vs. 3a***	4.79	3.11	--	5.17
	--	***df***	291	290	--	291
	--	***p***	.029	.046	--	.024
AIC (corrected)	7.348	***AIC***	8.595	9.225	11.356	8.213
BIC	9.320	***BIC***	10.566	11.189	13.335	10.185
28 years (YASR)	Model 1		Model 2a	Model 2b	Model 3a	Model 3b
B_0 (Intercept)	1.10 (.53)	**B_0**	**1.83 (.53)**	1.18 (.65)	**1.58 (.52)**	**1.29 (.52)**
B_1 (sensitivity)	-.16 (.09)	**B_1**	.00 (-)	-.30 (.20)	.00 (-)	**-.39 (.13)**
B_2 (RP group)	**.36 (.13)**	**C**	-2.92 (2.85)	2.04 (2.44)	1.18 (-)	1.18 (-)
B_3 (interaction)	--	**B_3**	-.12 (.10)	-.12 (.10)	.07 (.08)	-.10 (.01)
R^2	.06	***R^2***	.06	.06	.03	.06
	--	***F vs. 2b***	2.36	--	5.15	0.33
	--	***df***	297	--	297	297
	--	***p***	.125	--	.006	.564
	--	***F vs. 3a***	7.895	5.148	--	9.983
	--	***df***	298	297	--	298
	--	***p***	.005	.006	--	.002
AIC (corrected)	-6.691	***AIC***	-4.999	-5.326	0.843	-7.054
BIC	-4.719	***BIC***	-3.027	-3.361	2.823	-5.082

Please note: AIC, Akaike information criterion; BIC, Bayesian information criterion. Significant parameters are marked bold. F versus 2b/3a stands for an F test of the difference in R^2 for a given Model versus Model 2b/3a. All models are controlled for gestational age at birth (B = -.04 to .05).

Table S3. Comparison of alternate regression models testing effects of maternal sensitivity at age 6 years on RP versus non-RP individuals' externalizing behaviour problems at 8 and 28 years

			Reparametrized regression equations			
	Main effects (ME)		**Differential Susceptibility (DST)**		**Diathesis-Stress (DIA-S)**	
			Strong:	Weak:	Strong:	Weak:
8 years (CBCL)	Model 1		Model 2a	Model 2b	Model 3a	Model 3b
B_0 (Intercept)	-.86 (.52)	**B_0**	-.30 (.52)	-1.45 (2.52)	-.55 (.52)	-.89 (52)
B_1 (sensitivity)	**-.26 (.09)**	**B_1**	.00 (-)	-.33 (.20)	.00 (-)	**-.42 (.12)**
B_2 (RP group)	**.26 (.13)**	**C**	-.94 (.70)	3.41 (9.43)	1.18 (-)	1.18 (-)
B_3 (interaction)	--	**B_3**	**-.25 (.11)**	**-.25 (.11)**	-.04 (.01)	**-.22 (.10)**
R^2	.04	***R^2***	.04	.04	.00	.04
	--	***F vs. 2b***	2.78	--	6.05	0.43
	--	***df***	290	--	290	290
	--	***p***	.097	--	.003	.514
	--	***F vs. 3a***	9.26	6.05	--	11.69
	--	***df***	291	290	--	291
	--	***p***	.003	.003	--	.001
AIC (corrected)	-24.705	***AIC***	-22.022	-22.765	-14.833	-24.400
BIC	-22.734	***BIC***	-20.050	-20.801	-12.854	-22.429
28 years (YASR)	Model 1		Model 2a	Model 2b	Model 3a	Model 3b
B_0 (Intercept)	-.73 (.55)	**B_0**	-.17 (.54)	-1.75 (8.13)	-.41 (.54)	-.66 (.54)
B_1 (sensitivity)	-.18 (.09)	**B_1**	.00 (-)	-.21 (.20)	.00 (-)	**-.34 (.13)**
B_2 (RP group)	**.27 (.14)**	**C**	-1.44 (1.20)	7.31 (44.06)	1.18 (-)	1.18 (-)
B_3 (interaction)	--	**B_3**	-.18 (.11)	-.18 (.11)	.00 (.08)	-.14 (.10)
R^2	.03	***R^2***	.02	.03	.00	.03
	--	***F vs. 2b***	1.11	--	3.93	0.67
	--	***df***	297	--	297	297
	--	***p***	.293	--	.021	.414
	--	***F vs. 3a***	6.75	3.93	--	7.20
	--	***df***	298	297	--	298
	--	***p***	.010	.021	--	.008
AIC (corrected)	9.163	***AIC***	10.261	11.204	14.970	9.815
BIC	11.135	***BIC***	12.234	13.169	16.950	11.787

Please note: AIC, Akaike information criterion; BIC, Bayesian information criterion. Significant parameters are marked bold. F versus 2b/3a stands for an F test of the difference in R^2 for a given Model versus Model 2b/3a. All models are controlled for gestational age at birth (B = -.04 to .05).

Figure S1. Flow diagram of participants