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Permalink

<https://escholarship.org/uc/item/0227d4zh>

Journal

Psychophysiology, 53(1)

ISSN

0048-5772

Authors

Waters, Sara F
Boyce, W Thomas
Eskenazi, Brenda
[et al.](#)

Publication Date

2016

DOI

10.1111/psyp.12539

Peer reviewed

The impact of maternal depression and overcrowded housing on associations between autonomic nervous system reactivity and externalizing behavior problems in vulnerable Latino children

SARA F. WATERS,^{a,b} W. THOMAS BOYCE,^c BRENDA ESKENAZI,^d AND ABBEY ALKON^e

^aDepartment of Psychiatry, University of California, San Francisco, San Francisco, California, USA

^bDepartment of Human Development, Washington State University, Vancouver, Washington, USA

^cDivision of Developmental-Behavioral Pediatrics, University of California, San Francisco, California, USA

^dCenter for Environmental Research and Children's Health, University of California, Berkeley School of Public Health, Berkeley, California, USA

^eSchool of Nursing, University of California, San Francisco, San Francisco, California, USA

Abstract

The study of autonomic nervous system responses and contextual factors has shed light on the development of children's negative outcomes, but the majority of these studies have not focused on minority populations living under adversity. To address these gaps, the current longitudinal study included a sample of poor, immigrant Latino families to examine whether associations between children's autonomic nervous system reactivity at 6 months and their externalizing behavior problems at 7 years of age were moderated by two risk factors associated with poverty: the interpersonal factor of chronic maternal depression and the environmental factor of chronic overcrowded housing. Multiple linear regression ($N = 99$) revealed that children who exhibited less parasympathetic nervous system withdrawal in response to challenge during infancy had more externalizing problems during childhood only if they had mothers who experienced chronic depression. Children who exhibited greater sympathetic nervous system reactivity during infancy had the lowest levels of externalizing problems during childhood only if they had mothers who chronic depression. Chronic overcrowded housing did not moderate associations between physiological reactivity and level of externalizing problems. These findings extend our understanding of the interaction of physiology and context on child outcomes to the understudied population of impoverished Latino families.

Descriptors: Latino, Autonomic nervous system, Externalizing behavior problems, Maternal depression, Overcrowding

Children vary in their biological responses to their environment, and these individual differences may have powerful influences on their behavior and psychosocial adjustment. When young children's home environments are fraught with harsh conditions and adversity, as in the case with economically impoverished, low-socioeconomic status populations, children are at significant risk for a host of difficulties including externalizing behavioral problems. Young children with persistent externalizing problems face long-term negative outcomes including low academic achievement and poor interpersonal relationships (Campbell, Spieker, Burchinal, Poe, & The NICHD Early Child Care Research Network, 2006).

While the field of developmental psychophysiology has examined the experiences of families with low-socioeconomic status and

families living in poverty, few studies have focused on poor Latino families. Latinos are the largest minority in the United States today (U.S. Census Bureau, 2010) and are heavily overrepresented among our poorest families (King, 2013 as cited by kidsdata.org) and those with the least access to health care (De Jesus & Xiao, 2014). We need to understand the relationship between Latino children's physiological responses and their behavioral outcomes in the context of poverty to support this highly vulnerable and growing population succeed in school and in the labor force.

Autonomic Nervous System Reactivity and Behavior

Children's physiological responses to environmental stimuli may influence their psychosocial development. Individual differences in children's physiological responses can be measured by changes in activation of the autonomic nervous system (ANS) when children shift from a resting state to a challenging state. The ANS consists of two branches—the parasympathetic nervous system (PNS) and the sympathetic nervous system (SNS)—enabling researchers to investigate recovery and restorative processes of the body as well

This publication was made possible by the National Institute of Child Health and Development (NICHD) RO3 HD058091, National Institute for Environmental Health Sciences (NIEHS) grant ES009605, and U.S. Environmental Protection Agency (US EPA) grants R826709011 and RD83171001.

Address correspondence to: Abbey Alkon, UCSF School of Nursing, 2 Koret Way, San Francisco, CA 94143-0606, USA. E-mail: abbey.alkon@ucsf.edu

as fight or flight responses (Kreibig, Wilhem, Roth, & Gross, 2007). Porges's polyvagal theory posits that PNS responses index activation of a social engagement system via the influence of the cardiac vagal nerve on the heart. This theoretically reflects an individual's ability to modulate social-emotional responses to environmental stimuli (see Porges, 2007, for a review). PNS responses are most commonly measured by changes in respiratory sinus arrhythmia (RSA) or the periodic oscillation in the cardiac sinus rhythm occurring at the frequency of respiration. The vast majority of psychophysiological studies of young children have focused on RSA responses without assessment of the SNS. SNS responses are measured by the preejection period (PEP) of the cardiac cycle or the time interval in milliseconds of the onset of ventricular depolarization and the onset of left ventricular ejection. ANS responses can be conceptualized in terms of a two-dimensional model of autonomic control in which PNS and SNS changes are flexible and responsive to each other (Berntson, Cacioppo, & Quigley, 1991). Nevertheless, there is a relative lack of SNS measurement in developmental research and, in order to fully understand the link between ANS responses and behavior, both branches need to be considered (Korte, Koolhaas, Wingfield, & McEwan, 2005).

While some studies have found a direct negative association between children's parasympathetic withdrawal and externalizing behavior problems (Calkins, Graziano, & Keane, 2007; Utendale et al., 2014), several theories posit that the influence of individual differences in ANS responses on behavior occurs not directly but as an interaction with the environment (Boyce & Ellis, 2005; Treadwell, Alkon, Quirolo, & Boyce, 2010). A large body of evidence links low-socioeconomic status and poverty to negative child outcomes (see Bradley & Corwyn, 2002 and Yoshikawa, Aber, & Beardslee, 2012, for reviews), but poverty is a proxy for a variety of adversities. Measuring contextual risk conceptually in terms of poverty offers limited utility for identifying the adversities poor children face that are the most salient challenges to psychosocial adjustment. Understanding specific poverty-related risk factors and how they are associated with children's physiology and psychosocial adjustment will enable researchers to develop targeted interventions to support healthy development. Our goal in the current study was to unpack the construct of poverty and examine the impact of two constituent risk factors—chronic maternal depression and chronic overcrowded housing—on associations between physiology and behavior.

Maternal Depression

An extensive body of research has demonstrated the negative effects of maternal depression on child outcomes (see Goodman, 2007, for a review), with small to moderate effect sizes obtained for maternal depression on children's externalizing problems (Goodman et al., 2011). This effect is highly salient given that roughly 10%–15% of mothers experience depression in the United States per year (Ertel, Rich-Edwards, & Koenen, 2011). Mothers who are depressed may not demonstrate consistent, appropriate, and emotionally positive responsiveness to their infant's needs (NICHD Early Child Care Research Network, 1999). For instance, Albright and Tamas-LeMonda (2002) found that higher rates of depressive symptomatology negatively predicted low-income mothers' sensitivity, affection, and effective communication with their infants. High-quality mother-child interactions foster children's healthy emotional and cognitive development (Harrist & Waugh, 2002), explaining, in part, the association between maternal depression and children's emotional dysregulation (Maughan,

Cicchetti, Toth, & Rogosch, 2007) and cognitive difficulties (Grace, Evindar, & Stewart, 2003). Furthermore, maternal depression may be a link between children's physiology and their behavior. For instance, Blandon, Calkins, Keane, and O'Brien (2008) found that children with less RSA withdrawal in response to mother-child interactions exhibited more social-emotional difficulties, if they had mothers with depression. Relatedly, children with less RSA withdrawal in response to a challenge had more problematic sleep, but again only if they had mothers with depression (Keller, Kouros, Erath, Dahl, & El-Sheikh, 2014).

Rates of depression among low-income, minority mothers are higher than rates among White mothers, with reports ranging from 25% to nearly 60% (Knitzer, Theberge, & Johnson, 2008; Lennon, Blome, & English, 2001). For Latina mothers, specifically, depression is associated with a greater number of other adversities, including poverty, unemployment, financial crisis, and divorce (Ertel et al., 2011). Latina women are also less likely to receive mental health services than poor White women (Alegria et al., 2002). Thus, understanding the ways in which maternal depression affects children growing up in Latino families with depressed mothers is especially salient. Very little work to date has focused exclusively on Latino families (Ainsberg, Trickett, Mennen, Saltzman, & Zayas, 2007; Huang, Lewin, Mitchell, & Zhang, 2012). Our investigation of maternal depression as a moderator of the relationship between children's ANS responses and externalizing behaviors in an entirely Latino sample addresses this gap in the field.

Overcrowded Housing

An adverse home environment is among the many challenges faced by children living in poverty and has significant negative implications for child development (Deater-Deckard et al., 2009; Evans, 2006; Evans, Saltzman, & Cooperman, 2001). Central to an adverse home environment is overcrowded housing (Leventhal & Newman, 2010), which has been shown to undermine the quality of interpersonal relationships, psychological well-being, and physiological functioning in adult samples (Evans, Palsane, Lepore, & Martin, 1987; Gove, Hughes, & Galle, 1979). Overcrowded housing has also been linked to less sensitive and responsive parenting and more negative parent-child interactions (Evans, Maxwell, & Hart, 1999; Gove et al., 1979). It is hypothesized that these effects are a function of pressure on social relationships due to lack of private space, overstimulation, and environmental chaos (Evans, Lepore, Shejwal, & Palsane, 1998).

Several studies have found that children living in overcrowded housing are more likely to have psychosocial health problems (Evans, Saegert, & Harris, 2001). In a longitudinal study of nearly 2,000 children from ages 3 to 17 years, Solari and Mare (2012) found that increases in overcrowding over a 4-year period significantly predicted externalizing behavior problems and poor physical health, even after controlling for socioeconomic status and other demographic variables. Some evidence also exists for an association between overcrowding and children's physiological responses (Aiello, Nicosia, & Thompson, 1979). Evans and colleagues (1998) found that 10- to 12-year-old children in overcrowded living conditions exhibited higher blood pressure at rest than children living in more optimal conditions. Our investigation of overcrowded housing as a moderator of the relationship between children's ANS responses and externalizing behaviors in an entirely Latino sample has not been addressed in the literature.

We examined the effects of children's ANS reactivity at 6 months of age on externalizing behavior problems at 7 years old as moderated by the interpersonal risk factor of chronic maternal depression and the environmental risk factor of chronic overcrowded housing. We focused on ANS responses at 6 months, the earliest age at which ANS responses were collected in this study, to provide a measure of individual differences in physiological reactivity. In contrast to the majority of developmental psychophysiological studies, we collected data on children's SNS responses using the cardiovascular index, PEP, enabling us to model the simultaneous effects of PNS and SNS responses independent of and controlling for each other. We used a parent-completed measure of behavior problems assessed at 7 years as the outcome variable because clinically relevant indicators of psychopathology are more reliably measured in older children. The two risk factors on which we focused were each measured at least twice in the intervening period of the child's development. Thus, we were able to examine the effects of risks experienced chronically during the first several years of life when the child's relationships with the mother and their home environment are centrally important.

We hypothesized that chronic depression in Latina mothers would moderate the association between ANS responses and behavior such that children who exhibited less PNS withdrawal and less SNS activation and whose mothers were depressed would have the highest rates of externalizing problems in childhood. We also expected to find a similar pattern of moderation for chronic overcrowded housing.

Method

Participants

The participants were drawn from a larger birth cohort, The Center for the Health Assessment of Mothers and Children of Salinas (CHAMACOS), which was designed to examine the relationship between environmental exposures and health of pregnant women and their children living in an agricultural community in Salinas Valley, Monterey County, California. Women in the first half of their pregnancy were recruited between October 1999 and October 2000 from six prenatal clinics. Eligible women were 18 years of age or older, less than 20 weeks gestation, Spanish or English speaking, eligible for California's low-income health insurance program (Medi-Cal), and planning to deliver at the county hospital. Further details of the larger study have been described elsewhere (Eskenazi et al., 2003).

Six hundred and one women were initially enrolled in the study, 526 were followed through delivery and 428 of their infants were seen at the 6-month visit, 418 at the 1-year visit, 330 at the 3.5-year visit, 319 at the 5-year visit, and 349 at the 7-year visit. Forty-two percent of infants at the 6-month visit participated in the ANS reactivity protocol and 17% of these files were not usable due to equipment failure, electrode displacement, or noisy data to child movement. Of the participants with valid ANS data at 6 months, 66% also had externalizing behavior data at age 7 years. Thus, there were 99 families included in the current sample.

Of these 99 mothers, 100% identified as Latina, 92% were born in Mexico, and 94% spoke mostly or only Spanish at home. Seventy-nine percent of mothers had less than a high school education, 84% were married or living as married with the child's father. At the time of enrollment, 65% of families lived at or below the

federal poverty level (FPL), 32% of families lived between 100% and 200% below the FPL, and the remaining 3% of families lived above 200% of the FPL. Sixty-one percent of families lived at or below the FPL at the 5-year visit as well. At the 6-month visit, 99% of families received the supplemental nutrition program for Women, Infants, and Children (WIC) and this percentage decreased to 76% by the 5-year visit. Mothers were, on average, 26.49 years old at the child's birth ($SD = 4.75$ years, range: 18–42), 26% were primiparous, and 92% of births were full term. Fifty-two percent of children were female and were on average 6.62 months old ($SD = 0.84$, range: 5.5–8.8) at the 6-month visit.

The current sample ($n = 99$) and the larger sample with behavior data at 7 years of age ($n = 384$) did not differ in demographic characteristics (ps from .17 to .96) except for child sex and maternal age. There were significantly more girls in the larger sample than the current sample, $\chi^2(1, N = 384) = 4.7, p = .03$, and mothers in the current sample were slightly younger than those in the full sample, $F(1, 383) = 5.23, p = .02$.

Procedures

The University of California (UC), Berkeley's and UC, San Francisco's institutional review boards approved the study protocols and consent forms. Prior to data collection at each time point, informed consent was obtained from one of the child's guardians. Mothers were interviewed for demographic and socioeconomic information during pregnancy, after delivery, and when the children were 6 months, 1, 2, 3.5, 5, and 7 years old by bilingual, bicultural interviewers in the mother's language of choice (i.e., Spanish or English). At the 6-month visit, infants completed a 7-minute standardized ANS reactivity protocol throughout which they were seated on their mothers' laps. The protocol began with a 2-minute rest period in which the infant listened to a recording of a lullaby, followed by three 1-minute challenges: (1) the infant watched the interviewer wind a jack-in-the-box toy three times, (2) the infant felt a vibrator placed by the experimenter on each of his/her legs, and (3) the infant listened to an audio recording of a sick baby crying. The protocol concluded with another 2-minute rest period in which the infant listened to a second lullaby (Alkon et al., 2006). The three challenges were designed to function as cognitive, physical, and social-emotional challenges, respectively, in line with the work of Boyce and colleagues (1995) in older children. Data from the second resting period were not used in the current study. At the 1- and 3.5-year visits mothers also completed a survey of depressive symptoms via interview, and at the 7-year visit, they completed a survey of their child's behavior problems, again via interview.

Measures

Demographics. Mothers completed a demographics questionnaire via interview at enrollment that included number of total years mother had spent in the United States.

Chronic maternal depression. Mothers completed the Center for Epidemiologic Studies-Depression Scale (CES-D; Radloff, 1977) at the 1- and 3.5-year visits. The CES-D is a 20-item inventory of symptoms experienced in the previous week, reported on a five-point Likert scale. Possible scores range from 0 to 60 with scores above 16 indicating potential clinical significance. Chronic maternal depression was created as a continuous variable by averaging

Table 1. Descriptive statistics and Pearson correlations between study variables

	<i>M (SD)</i>	Range	1	2	3	4	5
1. Maternal years in U.S.	7.72 (6.92)	0.08–27.14					
2. Chronic maternal depression	16.73 (10.24)	1.0–47.50	-.14				
3. Chronic overcrowded housing	2.20 (0.54)	1.0–3.0	-.12	-.17 ⁺			
4. Child RSA reactivity	0.01 (0.60)	-2.09–1.72	-.07	.01	-.08		
5. Child PEP reactivity	0.67 (3.16)	-8.67–9.0	-.02	.13	.10	-.08	
6. Externalizing problems	134.30 (20.27)	104–196	.15	.24*	-.08	.17+	.08

Note. $n = 94$ for chronic maternal depression; $n = 97$ for child RSA reactivity; $n = 92$ for child PEP reactivity; $n = 99$ for other variables; * $p < .05$; ⁺ $p < .10$.

the total scores across the two time points. Participants who had data at only one time point were not included in analyses ($n = 5$).

Chronic overcrowded housing. We measured household density by the number of people living in the household divided by the number of rooms, excluding bathrooms. Families with more than 1.5 people per room were indicated as overcrowded, and those families with fewer persons per room were not (Econometrica, Blake, Kellerson, Simic, & ICF International, 2007). Housing density data collected at the 1-, 3.5-, and 5-year visits were used to form an index of chronic overcrowded housing by averaging the dichotomous variables across the three points. All participants had at least two time points of data.

ANS reactivity. We measured electrocardiography (ECG), respiration, and impedance cardiography (Biopac MP150 Data Acquisition System, Biopac Systems, Inc., www.biopac.com) continuously throughout the 6-month ANS protocol to obtain children's PNS reactivity measured by RSA, and SNS reactivity measured by PEP. Four spot electrodes were placed on the neck and trunk to collect impedance and respiratory measures, and three spot electrodes were placed on the right clavicle, lower left rib, and right abdomen for ECG measures (Alkon et al., 2006).

ANS data were filtered, extracted, and then scored in 1-minute intervals using Mindware software (Heart Rate Variability Analysis Software 2.6 and Impedance Cardiography Analysis Software 2.6, Mindware Technologies, Ltd, www.mindwaretech.com). Minute-by-minute data cleaning procedures involved examining for artifact and an individual child's data were deleted if more than 25% of the task minutes were unscorable. Eight children had RSA data but lacked PEP data and two children had PEP data but lacked RSA data.

Consistent with the field standard, RSA and PEP reactivity scores were calculated by subtracting the average response during the first 2-minute rest period from the average response across the three challenges (Matthews, 1986). Thus, a negative RSA reactivity score indicates greater PNS withdrawal during the challenges than at rest and a negative PEP reactivity score indicates greater SNS activation during the challenges than at rest.

Child externalizing problems. Mothers reported on children's behaviors at the 7-year visit via the Behavior Assessment System for Children 2 (BASC-2; Reynolds & Kamphaus, 2004). The 160-item inventory measures how often the child exhibits certain behaviors in the home setting rated on a four-point Likert scale. The raw scores from the externalizing behavior problems composite were used. This composite consists of the aggression, conduct problems, and hyperactivity subscales and has a range of 101 to 362.

Data analysis

We conducted statistical analyses using SPSS 21.0. Descriptive statistics were calculated for all demographic characteristics and study variables. Outliers of >3 *SD* from the mean were identified for each study variable. By this criterion, four participants were excluded from the final sample ($n = 3$ outliers on child externalizing problems, $n = 1$ outlier on maternal years in the United States). Pearson correlation coefficients were used to explore the relationship between key study variables. We constructed stepwise multiple linear regression models to examine the impact of child physiology on externalizing problems as moderated by chronic maternal depression and chronic overcrowded housing. Child sex and maternal years in the United States were entered as covariates. Variables were centered by subtracting the sample mean from the individual value before interaction terms were formed. Statistically significant ($p < .05$) and marginally significant ($p < .10$) interaction terms were examined using the simple slopes technique (Aiken & West, 1991) by comparing the effect of adversity (i.e., maternal depression and overcrowded housing) on children's externalizing problems at greater and less RSA or PEP reactivity (1 *SD* below the mean and 1 *SD* above the mean, respectively).

Results

Descriptive statistics and bivariate correlations between study variables are shown in Table 1. The mean chronic maternal depression scores met the threshold for clinical significance and, on average, families lived in overcrowded housing at two of the three time points. Children's ANS reactivity scores were, on average, positive, indicating that, in response to the challenges, children exhibited less RSA withdrawal and less PEP activation than during rest.

We found a marginal, negative correlation between RSA reactivity and externalizing problems, indicating that children with less RSA withdrawal at 6 months had higher levels of externalizing problems at 7 years. Children's ANS reactivity scores were not associated with chronic maternal depression at 1 and 3.5 years. We also found no association between household crowding and ANS responses. Children whose mothers experienced chronic depression had higher levels of externalizing behavior problems at 7 years, but chronic overcrowded housing was not associated with externalizing behavior problems.

We tested for sex differences in physiological reactivity variables and externalizing problems. There were no significant differences by sex for RSA reactivity ($M_{girls} = -0.013$, $SD = 0.60$ and $M_{boys} = 0.037$, $SD = 0.60$), $t(95) = 0.36$, $p = .72$, 95% CI [-1.99, 0.29]) or PEP reactivity at age 6 months ($M_{girls} = 0.88$, $SD = 0.45$ and $M_{boys} = 0.46$, $SD = 0.49$), $t(90) = -0.64$, $p = .52$, 95% CI [-1.74, 0.89]). Furthermore, girls and boys had comparable externalizing problem scores at 7 years of age ($M_{girls} = 133.69$,

Table 2. Chronic maternal depression moderates the association between child RSA and PEP reactivity and externalizing problems

	b	SE	β	t-statistic	p-value	95% CI	
Maternal years in U.S.	0.24	.31	0.09	0.79	.434	-0.37	0.85
Child sex	-0.20	3.86	-0.01	-0.05	.958	-7.90	7.49
Chronic maternal depression	0.30	0.20	0.17	1.47	.146	-0.11	0.70
Chronic overcrowded housing	-1.21	3.84	-0.03	-0.31	.754	-8.86	6.44
Child RSA reactivity	8.38	3.74	0.24	2.24	.028	0.92	15.83
Child PEP reactivity	1.25	0.68	0.20	1.83	.072	-0.11	2.61
Depression X RSA	1.10	0.52	0.26	2.11	.038	0.06	2.14
Depression X PEP	-0.11	0.06	-0.21	-2.00	.049	-0.23	-0.001
Housing X RSA	8.02	7.64	0.12	1.05	.297	-7.21	23.25
Housing X PEP	0.88	1.59	0.06	0.55	.581	-2.29	4.06

Note. $F(10, 74) = 2.198, p = .03, R^2 = .229$; b = unstandardized beta; β = standardized beta.

$SD = 20.41, M_{boys} = 134.88, SD = 20.31, t(97) = 0.29, p = .77, 95\% CI [-6.93, 9.32]$.

The omnibus test for the full model and all coefficient statistics are shown in Table 2. The first step of the regression included chronic maternal depression and chronic overcrowded housing as predictors and maternal years in the United States and child sex as covariates. Together these variables explained 5% of the variance in levels of externalizing behavior problems at 7 years. Chronic maternal depression was a significant predictor. The maternal years in the United States variable was marginally significant. Step two introduced child RSA reactivity and PEP reactivity, explaining an additional 5% of the variance in the outcome ($F_{change}(2, 78) = 2.42, p = .096$). At this step, with RSA and PEP reactivity in the model, chronic maternal depression and child RSA reactivity were both marginally significant positive predictors of externalizing behavior problems. Step three introduced the four interaction terms, which explained an additional 8% of the variance in the outcome ($F_{change}(4, 74) = 1.93, p = .12$). Significant main effects for both child ANS reactivity variables were qualified by significant effects for the chronic maternal depression by child RSA reactivity interaction term and the chronic maternal depression by child PEP reactivity interaction term.

As shown in Figure 1, children with mothers with high chronic depression who exhibited less PNS withdrawal during the challenge compared to rest (i.e., less RSA reactivity) had the highest levels of externalizing problems at 7 years, $t(74) = 3.98, p < .001, 95\% CI [10.04, 30.17]$. Children with mothers with high chronic depression who exhibited greater PNS withdrawal during the challenge compared to rest (i.e., greater RSA reactivity) had the lowest

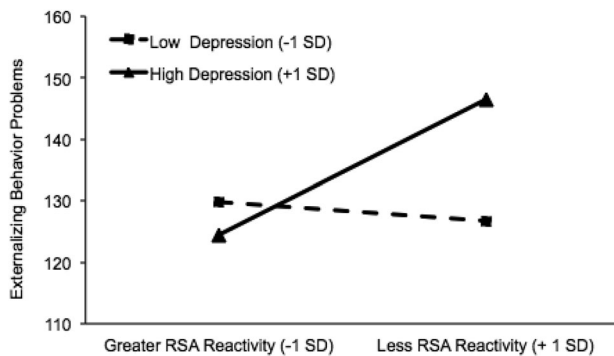


Figure 1. Chronic maternal depression moderates the association between child RSA reactivity at six months of age and externalizing behavior problems at seven years of age.

levels of externalizing behavior problems at 7 years. For children whose mothers did not have chronic depression, there was no difference in the levels of externalizing behavior problems as a function of PNS withdrawal, $t(74) = -0.59, p = .55, 95\% CI [-12.37, 6.69]$.

As shown in Figure 2, for children with mothers with high chronic depression, SNS activation during the challenge compared to rest at 6 months was negligibly associated with externalizing problems at 7 years, $t(74) = 0.01, p = .99, 95\% CI [-6.32, 6.41]$. However, children whose mothers did not have chronic depression and who had greater SNS activation during the challenges compared to rest (i.e., greater PEP reactivity) had the lowest levels of externalizing problems at 7 years of age, $t(74) = 0.72, p = .47, 95\% CI [-4.24, 9.04]$. This finding should be interpreted conservatively because neither slope was statistically significant.

Discussion

In this cohort study of poor Latino children, we found partial support for our hypothesis children who exhibited less PNS withdrawal during the challenges compared to their resting state at 6 months and whose mothers had chronic depression during their early childhood had the highest levels of externalizing behavior problems at 7 years of age. Unexpectedly, we found children with greater SNS activation during the challenges compared to their resting state and whose mothers chronic depression had the lowest levels of externalizing behavior problems at 7 years of age. Our hypothesis that children with less PNS withdrawal and SNS activation during the challenge protocol compared to their rest state and who lived in

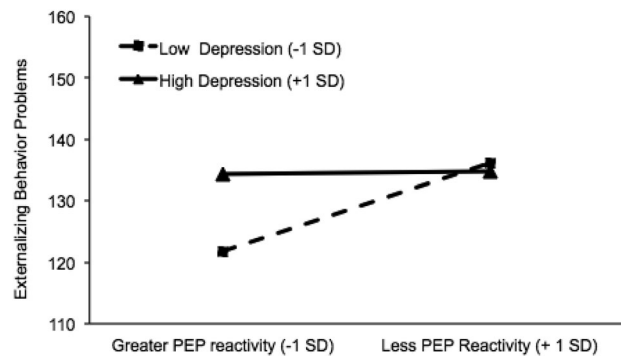


Figure 2. Chronic maternal depression moderates the association between child PEP reactivity at six months of age and externalizing behavior problems at seven years of age.

chronic overcrowded housing would have the highest levels of externalizing problems was not supported.

Our findings are notable for several reasons. Children's physiological reactivity was not robustly associated with their development of externalizing behavior problems. While some studies have found main effects of physiology on behavior, our results align with the field's growing recognition that these complex associations may be better understood as interactions with contextual adversities. We examined whether two specific risk factors—chronic maternal depression and chronic overcrowded housing—moderated the relationship between physiological responses and externalizing behavior problems. These interpersonal and environmental risk factors have documented links to negative child outcomes and are common in families living in poverty. We tested both chronic maternal depression and chronic overcrowded housing simultaneously and found that the former moderated the relationship between both parasympathetic (i.e., RSA) and sympathetic nervous system (i.e., PEP) responses and behavior, above and beyond the latter.

Greater parasympathetic withdrawal, which facilitates attention and focus, and moderate sympathetic activation, which indicates the body's preparedness to face a difficult situation, is an adaptive physiological response to a mildly stressful situation (Berntson et al., 1991), like our challenge protocol. Consistent with work in non-Latino samples, the children in our study who exhibited less parasympathetic withdrawal (e.g., Calkins et al., 2007) to the challenges in the ANS protocol during infancy had the highest levels of externalizing behavior problems at 7 years, but only those whose mothers were chronically depressed during early childhood. Our findings also align with others' work showing children with greater sympathetic activation have lower levels of externalizing behavior problems (e.g., Snoek, van Goozen, Matthys, Buitelaar, & van Engeland, 2004).

While the interaction of chronic maternal depression and children's RSA reactivity was robust, the interaction of depression and PEP reactivity was only marginally significant. This may be due to the large variance obtained in children's PEP measures. Less is known about the typical range of PEP responses than RSA responses in infants due to few impedance cardiography studies in very young samples. Given our rigorous data-cleaning protocol, we expect the variability observed in PEP responses may be due to the wide range of individual differences and not artifact or noise. Combined with the RSA reactivity findings, our results suggest that children who mounted an adaptive pattern of physiological response (i.e., greater parasympathetic withdrawal and greater sympathetic activation) to a challenge were buffered against the negative effects of chronic maternal depression on behavioral outcomes.

Contrary to our expectations, chronic overcrowded housing did not moderate the impact of physiology on behavior, nor was it a significant direct predictor of children's externalizing problems. There are several possible explanations for this null finding. While overcrowding has long been considered an important risk factor for negative outcomes in human and animal models (Evans et al., 1987; Hannon & Donlon-Bantz, 1976; Myers, Baer, & Choi, 1996), some recent research suggests that housing density is only one of a host of nonoptimal housing factors and may not be the most potent one. For instance, Martin, Razza, and Brooks-Gunn (2012) found that after controlling for ambient noise in the environment, amount of time television was left on, and family instability, overcrowded housing was no longer a significant predictor of children's aggression and attention problems. Few studies have

examined overcrowded housing in samples of very young children or with repeated measures over time as done in this study. These features are distinctive of the current work and make the discrepancies of our findings to previous studies challenging to interpret. It is also possible that the measure of overcrowded housing did not capture the variability significant for associations between physiology and behavior. It is worth noting that the psychological experience of overcrowding or not having enough personal space during early childhood may be one of the pathways by which overcrowding influences child development. Importantly, what is experienced as overcrowding may be culturally influenced. Future studies may complement the objective measure of overcrowding used in the current investigation with more subjective reports to better understand how housing density is experienced by poor, immigrant Latino families.

This study has several limitations to consider. The average level of externalizing problems in the sample was fairly low. While unexpected, relatively low levels of externalizing problems have been found in other studies of low-income Latino youth (Dennis, Parke, Coltrane, Blacher, & Borthwick-Duffy, 2003; Fomby & Eustacion, 2011). We identified the number of years mothers had spent in the United States as an important covariate, but we did not have standardized measures to investigate the potential influences of acculturation or cultural identity. Acculturation and acculturative stress may play roles in maternal mental health and child outcomes in Latino families (Cespedes & Huey, 2008; Torres, 2010) and future research should examine the role of acculturation in the link between children's physiological reactivity and psychosocial adjustment. While several of the measures we used were based on maternal report, which could introduce source bias, the hypothesized interaction effects involved the objectively measured ANS responses. Because our sample consisted of poor Latino families, it is difficult to generalize the findings to other populations. However, these findings provide insight into child development in a growing, at-risk, minority population.

This work has important implications for intervention and future research. The tendency for children with less parasympathetic withdrawal to exhibit higher externalizing problems held only for those children who were also exposed to mothers with chronic depression in the first 3.5 years of their lives. Thus, interventions that address maternal depression in young children's lives may help mitigate the development of behavior problems for some poor, Latino children. Given that Latinos may not have access to health insurance, future research should focus on ways to improve Latina mothers' access to mental health services. These interventions have the dual benefit of improving mothers' lives and decreasing children's externalizing problems before it affects their academic performance or peer relationships. The interpersonal risk factor of maternal depression was a more salient feature of the context of poverty than the environmental risk factor of chronic overcrowded housing, suggesting that a mental health services intervention may have a greater impact on children than an intervention to improve housing density conditions. The differential influences of these two risk factors also supports the call for future research to move from broad indices of adversity, such as poverty or low-socioeconomic status, to more specific risk factors to better understand the negative influences on children's development. In sum, the current study addressed several significant gaps in the literature and supports a deeper understanding of the complex interplay among physiological reactivity, poverty-related risk, and child behavioral outcomes in poor, Latino families.

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(RECEIVED November 3, 2014; ACCEPTED July 6, 2015)