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Parasympathetic Regulation and Support From Family and Friends Predict Prosocial Development in U.S. Mexican-Origin Adolescents

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Both parasympathetic nervous system regulation and receipt of social support from close relationships contribute to prosocial development, although few studies have examined their combined influences in adolescence and particularly within racially and ethnically minoritized populations. In this longitudinal study of 229 U.S. Mexican-origin adolescents (48% female-identifying), youths reported on receipt of social support from family and friends from 10 to 16 years, had their baseline respiratory sinus arrhythmia (RSA) measured at 17 years, reported their prosocial behavior and completed the Mind in the Eyes test to assess cognitive empathy at 17 and 19 years, and reported their prosocial civic behavior (i.e., community activity) at 19 years. Family social support predicted prosocial behavior at 17 years, and friend social support predicted prosocial civic behavior at 19 years. Compared to youths with lower or higher baseline RSA, youths with moderate RSA reported more prosocial civic behavior, had greater cognitive empathy, and tended to report more general prosocial behavior at 19 years. The quadratic association between baseline RSA and cognitive empathy was stronger for youths with greater family social support. These findings are the first to extend the evidence that moderate baseline parasympathetic nervous system activity supports prosocial development into late adolescence and with the U.S. Mexican-origin community, and these findings address calls for more integrative biopsychosocial studies of prosociality.

Public Significance Statement
This study shows that physiological regulation and social support from family and friends support prosocial development for U.S. Mexican-origin youths.

Keywords: prosocial, Mexican origin, adolescence, respiratory sinus arrhythmia, social support

Supplemental materials: https://doi.org/10.1037/dev0001780.supp

Empathy, sympathy, and prosocial behavior are other-oriented emotional and behavioral capacities that are indicators of personal well-being and promoters of positive interpersonal relationships and health across the lifespan (Carlo et al., 2022). Biopsychosocial models of prosocial development have become prominent in research on early childhood (Miller & Hastings, 2016, 2020), but few studies of prosociality in adolescence or with historically underrepresented populations have examined both neurobiological

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and social relationship influences on prosocial development (Carlo et al., 2022). The diverse Latinx communities constitute one of the fastest growing demographic groups within the United States (Frey, 2021); in California, more than half of children and adolescents identify as Latinx, and the majority of their families identify Mexico as their country of origin (Public Policy Institute of California, 2019). In this longitudinal study, we examined how Mexican-origin adolescents' parasympathetic nervous system (PNS) regulation and experiences of supportive family and friend relationships predicted the development of their cognitive empathy and prosocial behaviors. Building on theory (Eisenberg & Fabes, 1992; Hastings & Miller, 2014) and evidence for quadratic associations between baseline PNS activity and prosociality (Kogan et al., 2014; Miller et al., 2017), we tested the hypothesis that U.S. Mexican-origin adolescents with moderate baseline respiratory sinus arrhythmia (RSA), relative to those with lower or higher baseline RSA, would be more empathic and prosocial and particularly when they had more supportive relationships with their families and friends.

PNS Activity and Prosociality

The autonomic nervous system serves as the conduit for rapid and bidirectional communication between the brain and the body, coordinating preparedness to respond to salient events or stimuli (Brownley et al., 2000). It is comprised of two branches, the sympathetic nervous system that is often associated with "fight or flight" responses to potential threats or challenges, and the PNS. The PNS serves important calming and restorative functions, yet Porges' polyvagal theory (1995, 2007) has been central in advancing our understanding of the PNS from its early portrayal as the "rest and digest" system to being a critical component of the social engagement system (Porges & Furman, 2011).

From the first year of life, the PNS serves essential roles in brain–body regulation and coordinating emotional and social responses to others (Miller & Hastings, 2016), primarily through the vagus nerve (Brownley et al., 2000; Weissman et al., 2018). Because of the vagus nerve's tonic inhibition of heart rate, estimates of PNS activity can be quantified using measures of high-frequency heart rate variability (HRV), like RSA, which reflects how the vagus nerve synchronizes changes in cardiac activity with the respiratory cycle. There is considerable evidence that measures of tonic PNS activity, like baseline RSA, may serve as biomarkers for emotion regulation (Beauchaine, 2015), reflecting individual differences in the physiological capacity to manage attentional control and engage with personally relevant stimuli and situations (Porges, 2011). Individuals with higher baseline RSA are thought to have greater capacity to modulate somatic activity without engaging the fight-or-flight responses driven by the sympathetic nervous system, thereby supporting the ability to respond to others with cooperative, rather than defensive or aggressive, social behavior (Hastings & Kahle, 2019). Hence, it has been posited that having higher baseline RSA should support empathic and prosocial engagement with others in states of need (Hastings et al., 2006). Conversely, when faced with another's pain, sadness, distress or need, an individual with low baseline RSA may lack a core physiological capacity to modulate emotional contagion, leaving them prone to experiencing stress-related increases in arousal and negative emotionality, or a self-focused response of personal distress that would motivate withdrawal and avoidance, rather than engagement and assistance (Eisenberg, 2000).

Evidence for this association is mixed, however. Studies of children, youths, and adults have shown positive (i.e., Taylor et al., 2015), negative (i.e., Van der Graaff et al., 2016), and nonsignificant (i.e., Eisenberg et al., 1996) associations between baseline RSA and measures of prosociality (Hastings et al., 2023; Hastings & Miller, 2014). For example, emerging adults' performance on the Reading the Mind in the Eyes Test (RMET; Baron-Cohen et al., 2001), a widely used measure of cognitive empathy, has been found to be both positively (Quintana et al., 2012) and negatively (Soker-Elimaliah et al., 2020) correlated with baseline RSA, whereas Zahn-Waxler et al. (1995) reported that children's baseline RSA was not significantly related to behavioral measures of cognitive empathy. At least two arguments have been posed for why higher baseline RSA may not be consistently associated with prosocial emotions and behaviors. First, strong emotion regulation capacities associated with having higher RSA could be used to suppress empathic arousal, reducing an affective motivator of prosocial engagement (Zaki, 2014); indeed, higher baseline RSA has been associated with greater use of emotion suppression (Pu et al., 2010). Second, the PNS not only supports self-regulation; higher and lower baseline RSA may also reflect higher and lower thresholds for arousal, respectively (Hastings et al., 2000, 2006). Adults' baseline HRV is inversely associated with activation of multiple emotion-processing regions of the brain when observing emotional faces (Miller et al., 2019), suggesting that individuals with higher baseline RSA may not be as responsive to subtle cues of the need for prosocial responses, such as a sad facial expression.

Thus, while individuals with lower baseline RSA may have greater vigilance for threat-related environmental cues and preparedness for defensive coping responses like withdrawal, those with higher baseline RSA may be more likely to perceive cues as neutral and contexts as not necessarily requiring engagement (Beauchaine, 2015; Porges, 2011; Thayer et al., 2012). As empathy involves perceiving, recognizing, and vicariously resonating with another's emotional state (de Waal, 2008), some degree of arousal in response to another's distress, combined with some degree of emotion regulation to avoid having that arousal lead to personal distress, may be needed to motivate positive other-oriented responses. Therefore, whereas individuals with lower baseline RSA might be relatively lacking in emotion regulation capacities, those with higher RSA might be relatively lacking in attentiveness to and engagement with others' needs. Conversely, having moderate baseline RSA might demarcate the balance of threshold for arousal and emotion regulation that could confer a greater tendency for prosocial responsiveness.

This form of quadratic relation, an inverted U-shaped curve, between baseline RSA and prosociality has been observed in multiple studies. With nine samples of participants from three countries (Canada, China, United States), having moderate baseline RSA has been linked with greater empathy, sympathy, and prosocial behavior across multiple indices in preschool- to kindergarten-aged children (Clark et al., 2016; Miller et al., 2017), school-aged children (Acland et al., 2019; R. Zhang & Wang, 2019, 2020), and adults (Kogan et al., 2014). Conversely, two studies of 4- to 5-year-old children found the opposite, with moderate baseline RSA associated with lower empathic concern or sympathy, compared to

lower or higher RSA (Acland et al., 2019; MacGowan & Schmidt, 2021). This could suggest that the more frequently identified inverted U-shaped relation between baseline RSA and prosociality strengthens with age.

There remain several gaps in the research on the quadratic association between baseline RSA and prosociality. First, most studies have exclusively documented concurrent relations, with one study showing that moderate baseline RSA at preschool age predicts children's, mothers', and teachers' reports of greater prosociality 4 years later (Miller et al., 2017). Second, while the association has been shown for prosocial behaviors (i.e., sharing, helping, comforting) and emotions (i.e., affective empathy, sympathy), the sole study to assess cognitive empathy, or the ability to accurately recognize the emotional states of others, did not find the quadratic effect (MacGowan & Schmidt, 2021); rather, having lower RSA increased the tendency for more shy children to exhibit less cognitive empathy. Third, the quadratic effect has not been examined within adolescence, a period of prefrontal maturation that both supports increasing capacities for cognitive empathy (Blakemore, 2008) and contributes to PNS regulation (Weissman et al., 2018), and emerging adults perform better on the RMET than adolescents (Dorris et al., 2022; Dodell-Feder et al., 2020). Thus, late adolescence may be a period in which the relation between moderate baseline RSA and cognitive empathy strengthens. Fourth, the quadratic relation has not been examined within racially and ethnically minoritized populations. Rather than presuming the generalizability of findings, it is important to directly study whether the association of moderate baseline RSA with greater prosociality observed in predominantly European–American samples in the United States and Canada, and Chinese samples in China, are evident for nonmajority communities such as U.S. Latinx youth (Carlo et al., 2022). Finally, despite increased recognition of the need to examine multiple determinants of development within biopsychosocial models (Cicchetti & Toth, 2009) and initial evidence that aspects of warm and supportive parenting may strengthen associations between children's PNS reactivity and prosociality (Miller et al., 2020; Miller & Hastings, 2016), researchers have not considered how quadratic baseline RSA and the quality of important relationships may interact to predict prosocial development. The present study addressed these gaps.

Prosociality in Mexican-Origin Adolescents

Although most research on prosocial development has been conducted with primarily White, European-origin samples, U.S. Mexican-origin adolescents have been found to be more likely than European–American youths to offer help, share resources, and engage in other prosocial actions (Kagan & Knight, 1979; Knight et al., 1981). Many aspects of prosocial behavior are resonant with traditional Mexican values (e.g., *familismo*, *respeto*, *bien educado*) and are likely to be supported by ethnic socialization practices utilized in the homes of this community (Calderón-Tena et al., 2011; Carlo et al., 2014). Indeed, several family-related processes and traditional Mexican cultural values have been found to foster prosocial development in U.S. Mexican-origin children and adolescents (Carlo et al., 2022; Carlo, White, et al., 2018). Yet, there is no existing longitudinal work on the interplay between socialization factors (e.g., family and friend relationships) and physiological factors that contribute to prosociality in U.S. Mexican-origin adolescents (Carlo et al., 2022).

Furthermore, the transition from late adolescence into emerging adulthood often involves greater orientation toward and involvement in community and civic causes (C. Flanagan & Levine, 2010; Mahatmya & Lohman, 2012), which may contribute to overall well-being (Ballard et al., 2019). Prosocial behaviors by adolescents are most often studied as helping, comforting, and sharing with others with whom an adolescent is interacting directly. Prosocial civic behavior encompasses distinct activities, such as volunteering for community organizations and political participation, and is considered as an indicator of positive youth development (Wray-Lake & Sloper, 2016). Ethnically and racially minoritized youths have long been at the forefront of prosocial civic engagement aimed toward bettering communities and addressing structural inequities (Wray-Lake & Abrams, 2020). Endogenous (i.e., PNS regulation) and exogenous (i.e., family and friend support) factors may support older adolescents' preparedness to engage in autonomous prosocial activities outside of familiar contexts like home and school. Thus, examination of the biopsychosocial factors supporting U.S. Mexican-origin youths' engagement in prosocial civic behaviors is warranted (Torney-Purta et al., 2007).

Supportive Relationships With Families and Friends and Prosocial Development

Children and adolescents who have warm, close, and supportive relationships with their parents and other family members tend to be more prosocial and to increase in their prosociality over time (Hastings et al., 2015). Supportive parents and siblings may serve as models of caring, other-oriented modes of social engagement, may generate relationship contexts in which children are receptive to internalizing positive socialization messages, and may scaffold children's developing emotion regulation and autonomy, all of which could contribute to their prosocial orientation toward others (Hastings et al., 2023; Miller & Hastings, 2016). Although more prosocial children and youths likely also elicit more supportive behaviors from other family members, a multinational, longitudinal, cross-lagged study showed that greater parental acceptance predicted increases in children's self-reported prosociality over the transition into adolescence (Putnick et al., 2018). This effect was similar for mothers' and fathers' acceptance, for sons' and daughters' development, and for the nine countries in which families were studied. Analogously, close family relationships and positive parenting in U.S. Mexican-origin families predict adolescents' sympathy and prosocial behavior (Carlo et al., 2010, 2011; Carlo, White, et al., 2018). Thus, as has been observed with European–American families, supportive U.S. Mexican-origin families are likely to foster their adolescents' prosocial development.

Receiving support from peers and friends also predicts prosocial behavior (Hastings, Utendale, et al., 2007; Hastings, in press). As friend relationships become increasingly salient socialization contexts during adolescence (Smetana et al., 2006), friend support may become more influential for adolescents' prosociality. In a meta-analysis of 70 studies, both parent and peer relationship quality were significantly associated with adolescents' affective and cognitive empathy, with the association significantly stronger for peers than for parents (Boele et al., 2019). The studies in the meta-analysis lacked ethnic and racial diversity, but Carlo, Streit, et al.

(2018) also found that U.S. Mexican-origin adolescents reported more cognitive and affective empathy and prosocial behavior when they had more supportive friend relationships, as well as more supportive parent relationships.

Evidence for Conjoint Influences of RSA and Socialization for Prosocial Development

Numerous studies have documented that PNS regulation and parental socialization conjointly contribute to myriad indices of self-regulation and psychopathology (i.e., Eisenberg et al., 2012; Skibo et al., 2020), although these typically examine HRV as the moderator of socialization influences on development. Children's experiences also can shape how their neurobiological characteristics get expressed behaviorally (Hastings & Kahle, 2019; Sapolsky, 2004), and studies have shown that the predictive associations of children's RSA with their psychosocial functioning can vary depending on aspects of parental socialization (Hastings, Kahle, et al., 2014; Ugarte et al., 2021). Four studies with predominantly European–American samples have shown that affectionate or supportive parenting behavior moderates the influences of PNS reactivity on children's prosocial behavior (McQuade & Breaux, 2017; Miller et al., 2020; Miller & Hastings, 2016; Scrimgeour et al., 2016). For example, PNS reactivity to empathy-eliciting stimuli that were associated with young children's donation behavior (Miller et al., 2015) were even more strongly associated with generosity when mothers were highly compassionate (Miller et al., 2020; Miller & Hastings, 2016). As direct associations of PNS regulation with prosociality were enhanced in children of mothers who reported putting the needs of their children and others ahead of their own needs, it is plausible that children may be more prone to, or capable of, acting upon their physiological capacities for prosociality when they are in relationships that model or reinforce those same prosocial inclinations.

Considering studies with youths, in a predominantly ethnic/racial minoritized sample, Cui et al. (2019) reported that neither baseline RSA nor RSA reactivity to a provocative film were directly associated with youths' prosocial behavior, but parental acceptance positively predicted prosocial behavior in adolescents who showed decreased RSA; they did not examine interactions between parenting and baseline RSA. Van der Graaff et al. (2016) found that 17-year-old Dutch adolescents' baseline RSA was not directly associated with their empathic concern, but having higher baseline RSA predicted less empathic concern 1 year later for male adolescents in more conflicted parental relationships and for female adolescents in less supportive relationships (Van der Graaff et al., 2016). Conversely, among college students in China, peer attachment predicted prosocial behavior for those with lower baseline RSA but not higher RSA, and RSA did not moderate the association of parent attachment with prosocial behavior (Y. Zhang et al., 2020). Given these findings, PNS regulation in adolescents and emerging adults appears to function in conjunction with their experiences in close relationships to influence prosocial development, as has been observed in children.

In the somewhat small body of literature examining the interactive contributions of RSA and socialization to prosocial development, we have not identified any such studies conducted with U.S. Mexican-origin or other Latinx adolescents. Similarly, there has been scant examination of adolescents' friend or peer relationships, RSA, and prosocial development. No studies have examined whether socialization experiences or relationship quality moderate the nonlinear association of baseline RSA with prosociality. If it is the case that having moderate baseline RSA increases the likelihood of displaying empathy and prosocial behavior (i.e., Kogan et al., 2014), and if supportive relationships can strengthen the positive behavioral expression of PNS regulation (i.e., Miller et al., 2020), then we may expect that adolescents with moderate baseline RSA will be most likely to have strong cognitive empathy and engage in more prosocial behavior when they have supportive relationships with their families and friends. Expressed another way, having experienced more supportive relationships, compared to having experienced less supportive relationships, may increase the likelihood that youths with moderate baseline RSA will behaviorally express their physiological capacities for prosociality.

Gender and Adolescents' Prosociality

In general, girls tend to be more empathic and compassionate than boys, whereas boys are equally or more likely to engage in such prosocial actions as active helping (Eisenberg & Fabes, 1998; Zahn-Waxler & Hastings, 1999). Through gender-canalized pathways of prosocial development, similar influences could support girls evincing more emotion-oriented prosociality (e.g., showing concern) and boys evincing more agentic and action-oriented prosociality (e.g., cooperating with peers; Hastings et al., 2015; Hastings, McShane, et al., 2007). U.S. Mexican-origin adolescent girls report more emotion-oriented prosocial responses than boys (Carlo, White, et al., 2018; Hodge et al., 2023), but parent and peer support do not predict aspects of prosociality differently for girls and boys (Carlo, Streit, et al., 2018; Carlo, White, et al., 2018). Although there is justification for examining whether physiology or relationship quality are associated with prosociality differently for U.S. Mexican-origin adolescent girls and boys, there is not a sufficient basis for making specific predictions about any such differences.

Hypotheses

In this prospective longitudinal study, we examined the concurrent and predictive associations between U.S. Mexican-origin adolescents' baseline RSA and family and friend relationship experiences with their cognitive empathy, general prosocial behavior, and prosocial civic behavior. Hypothesis 1: We expected that adolescents with moderate baseline RSA would be more empathic and prosocial than adolescents with relatively lower or higher baseline RSA, with this inverted U-shaped curve evidenced by negative associations between quadratic RSA and the measures of empathy and prosocial behavior. Hypothesis 2: We predicted that youths who had received more family and friend support throughout their adolescent development would be more empathic and prosocial. Hypothesis 3: Acknowledging the limited prior research on the conjoint contributions of PNS regulation and relationship experiences to adolescents' prosocial development, and an absence of research specifically examining relationship qualities as moderators of nonlinear relations between baseline RSA and prosociality, we tentatively expected that family and friend support would serve as positive relationship contexts that would strengthen the quadratic association between baseline RSA and adolescents' empathy and prosocial behavior. Finally, adolescent gender was examined as a possible moderator of the associations posited in Hypotheses 1 and 2, but no a priori hypotheses were proposed.

Method

Transparency and Openness

De-identified data and materials described in this report are available from the corresponding author on request.

Participants

This study included 229 Mexican-origin adolescents (M_{age} = 17.16 years, SD = .44, 110 female[1]) recruited from the California Families Project, a prospective, longitudinal study of 674 U.S. Mexican-origin families, for participation in a neurobiological substudy. The California Families Project began when the children were in fifth grade (M_{age} = 10.86, SD = .50, 50% female). The substudy sample was recruited on the basis of adolescents' self-reported depression-related problems on the ninth grade (age 14) administration of the Diagnostic Interview Schedule for Children-IV (Shaffer et al., 2000) and General Distress and Anhedonic Depression subscales of the Mood and Anxiety Symptom Questionnaire (Watson & Clark, 1991). No youths scored in the clinical range of these instruments at 14 years. A dichotomous Depression Risk recruitment variable (1 = scored above the median on one or more measures, n = 175; 0 = scored below the median on all three measures, n = 54) was included as a covariate in all models. Two years after their first assessment in the neurobiological substudy, 177 adolescents (M_{age} = 19.05 years, SD = .59, 84 female; 77.3% retention) participated again, with 172 completing measures of prosociality. Participants who did not complete the follow-up assessment were older at the time of the first substudy assessment than were those who did, $t(227) = 3.73$, $p < .001$; participants who did versus did not complete the follow-up assessment did not differ significantly on any other demographic, RSA, social support, or age 17 prosociality measures, all $p > .340$.

Procedure

At Grades 5, 7, 9, and 11 (M_{ages} = 10.86, 12.81, 14.75, and 16.80 years, SD = .50, .49, .49, and .51, respectively), families were visited in their homes, and adolescents were administered the Multidimensional Scale of Perceived Social Support (MSPSS; Zimet et al., 1988). At Age 17, adolescents visited a hospital research center, where their baseline electrocardiographic (ECG) activity was recorded. After completing procedures not related to the current analyses for approximately 90 min, they then completed the RMET to assess cognitive empathy (Baron-Cohen et al., 2001) and reported on their prosocial behavior using the Strengths and Difficulties Questionnaire (SDQ; Goodman et al., 1998). Two years later, at Age 19, adolescents were again administered the RMET task and completed the SDQ, as well as items from the Civic Engagement Scale (CES; C. A. Flanagan et al., 2007). All youths were proficient in English and elected to complete measures in English.

Self-Report Measures

Social Support

The MSPSS included four items assessing adolescents' perceptions of family support (e.g., "When you feel bad, you get the help and support you need from your family.") and four items assessing youths' perceptions of friend support (e.g., "You can count on your friends when things go wrong."), rated on 4-point Likert-style scales ranging from 1 = *Not at all true* to 4 = *Very true*. The MSPSS had excellent internal consistency for both family and friend support, all coefficient $\alpha > .84$. Principal components analyses supported single-factor solutions for parent support and friend support across assessments (both eigenvalue >2.00, accounting for >50% of variance). Therefore, mean scores across assessments were averaged to obtain one measure of parent support and one measure of friend support across early to midadolescence.

General Prosocial Behavior

Five items assessing prosocial behavior on the SDQ (e.g., "I often offer to help others [parents, teachers, children]."") were rated on 3-point Likert-style scales from 0 = *Not true* to 2 = *Certainly true*. The SDQ Prosocial scale had acceptable internal consistency when youths were aged 17, α = .63, and 19, α = .73. SDQ data were missing for three adolescents at age 17.

Prosocial Civic Behavior

At age 19, six items from the Personally Responsible Citizen, Accountable, and Helping Others subscales of the CES (e.g., "It is important to me to help people in my community.") were rated on 5-point Likert-style scales from 1 = *Strongly Disagree* to 5 = *Strongly Agree*. The CES Prosocial Civic Behavior scale had excellent internal consistency, α = .87. CES data were missing for six adolescents at age 19.

Behavioral Measures

Cognitive Empathy

The RMET was administered to adolescents when they were aged 17 and 19. The version of RMET used for this study presented 28 images of faces expressing a variety of emotions, cropped to reveal only the eye region of the faces, with four emotion terms accompanying each image. Each of the 28 images appeared on its own page, with the pages contained within a binder in a set order. Youths had to choose one emotion term to describe the emotion they thought was being expressed by the eyes in each image. An examiner was present during the RMET, and if a youth did not know the meaning of a word, the examiner provided a definition or synonym. The RMET is a widely used measure of emotional perspective-taking with extensively documented validity and clinical utility (Baron-Cohen et al., 2001; Olderbak et al., 2015), with good test–retest reliability but low internal consistency (Olderbak et al., 2015). Similarly, internal consistency for this sample was low at age 17, α = .57, and very low at age 19, α = .17, but RMET cognitive empathy scores were significantly stable over 2 years, $r = .51$, $p < .001$. RMET data were missing for seven adolescents at age 17 and four adolescents at age 19.

[1] At the time of data collection, youths were not asked about gender identities other than female or male, and no youth spontaneously reported a nonbinary or transgender identity.

Physiological Measures

Baseline RSA

Adolescents' ECG data were recorded using three electrodes attached to an adolescent's chest by a gender-matched examiner and connected with a Biopac functional magnetic resonance imaging compatible wireless signal logging system (Biopac Systems, United States) via Siemens' telnet physiological monitoring unit at 400 Hz. There has been debate within the psychophysiological literature regarding whether respiratory rate should or should not be incorporated into the calculation of RSA and other indicators of PNS activity (Laborde et al., 2017). Therefore, two baseline measures of ECG data were collected from adolescents at age 17. After applying the electrodes and giving the adolescents several minutes to become accustomed to wearing them, youths were first asked to lie quietly on their back for 3 min while ECG data were recorded, and then they were asked to breath in time to a paced breathing video with a 5.5-s respiratory cycle for 90 s (16 breaths in 90 s). Due to human error or equipment malfunction, baseline ECG data were completely missing for 14 participants.

Data were converted into an ASCII formatted string of amplitude values and manually edited using Mindware HRV software (Mindware Technologies, Gahanna, OH). Interbeat intervals, measured by the elapsed time between subsequent local maxima in the QRS complex (*R*-spikes), were was used to calculate RSA (Berntson et al., 1997). ECG data were inspected visually by the third author and research assistants, who edited the data when the automated software misidentified the *R*-spikes. The frequency band used to quantify RSA was 0.12–0.40, the typical range of respiration rates for 16- to 17-year-olds (Shader et al., 2018) that also encompassed the paced breathing rate. Mindware computes RSA as the natural log of spectral power in this frequency band. RSA was computed in 30-s epochs, such that RSA during unpaced breathing was computed as the mean of six epochs, and RSA during paced breathing was computed as the mean of RSA during three epochs. As would be expected, paced breathing RSA was higher, $M = 8.49$, $SD = .86$, than unpaced breathing RSA, $M = 6.82$, $SD = .98$, paired $t(208) = 30.13$, $p < .001$, but adolescents showed high rank-order stability in RSA across the unpaced and paced breathing conditions, $r = .63$, $p < .001$. Therefore, recognizing the merits of arguments both for and against controlling for respiration and the value of using repeated measures of baseline physiology to establish more stable measures of individual differences, mean RSA across the two conditions was used as the measure of baseline RSA in all analyses.[2]

Analyses

Five stepwise multiple regression models were used to examine linear and quadratic effects of baseline RSA, family and friend support, and the interactive effects of RSA and support, as predictors of general prosocial behavior at Time 1 and Time 2, cognitive empathy at Time 1 and Time 2, and prosocial civic behavior at Time 2. In Step 1 of the regression models, age at initial recruitment, age at neurobiological testing, gender, and depression risk recruitment status were included as control variables, and linear RSA, quadratic RSA, family support, and friend support were included to test Hypotheses 1 and 2. We followed an orthogonal polynomial approach using the poly function in R Version 3.6.2 to define linear and quadratic baseline RSA while avoiding multicollinearity (Hastie & Chambers, 1992; Kennedy & Gentle, 1980). Models for Time 2 general prosocial behavior and cognitive empathy controlled for corresponding Time 1 scores. In Step 2 of the regression models, the four interactions terms for family and friend support moderating the associations of linear and quadratic RSA with prosociality measures were included to test Hypothesis 3. Significant interaction effects were probed by examining any association between linear or quadratic RSA with an aspect of prosociality at low (−1 *SD*), average (0 *SD*), and high (+1 *SD*) levels of family or friend support. Additionally, regions of significance analyses are included in the Supplemental Materials to further facilitate interpretation. For all models, full information maximum likelihood estimation was used to estimate model parameters and account for missing data.

For the exploratory examination of gender differences in the associations, models were run in which Step 2 included the four interactions terms for gender moderating the associations of linear RSA, quadratic RSA, family support, and friend support with prosociality measures.

Results

Descriptive statistics and zero-order correlations are presented in Table 1. Female adolescents had higher baseline RSA and reported more friend support, more general prosocial behavior at both Time 1 and Time 2, and more prosocial civic behavior at Time 2, compared to male adolescents. All adolescent-report measures were positively intercorrelated. Baseline RSA and cognitive empathy scores were not significantly correlated with support or prosocial behavior measures, although four positive associations approached significance. General prosocial behavior and cognitive empathy scores were moderately to highly stable from Time 1 to Time 2. Adolescents reported more family support than friend support, paired $t(228) = 2.19$, $p < .05$, and more general prosocial behavior on the SDQ at Time 2 than at Time 1, paired $t(168) = 2.22$, $p < .05$. Cognitive empathy scores did not change from Time 1 to Time 2, paired $t(161) = 0.60$, ns.

Hypothesis 1: Was There Evidence for Quadratic RSA Predicting Prosociality?

The models predicting general prosocial behavior and cognitive empathy at Time 1, general prosocial behavior and cognitive empathy at Time 2, and prosocial civic behavior at Time 2 are presented in Tables 2, 3, and 4, respectively. Statistics reflect the associations of the predictors with the dependent measures at the step of entry. There were no significant linear associations of RSA with any prosocial measures. The quadratic RSA term was not significantly associated with concurrent prosocial behavior or cognitive empathy at 17 years. Quadratic RSA significantly and negatively predicted changes in cognitive empathy from 17 to 19 years and prosocial civic behavior at

[2] Models using just paced breathing RSA and just unpaced breathing (natural) RSA were also examined. There were stronger effects of quadratic RSA predicting the various indicators of prosociality in the models for paced breathing RSA ($n = 3$) compared to the models for unpaced breathing RSA ($n = 1$). Conversely, there were more significant interactions between social support and RSA, including for both linear RSA and quadratic RSA, in the models for unpaced breathing RSA ($n = 5$) compared to the models for paced breathing RSA ($n = 0$). Details on these models are available in the Supplemental Materials.

Table 1

Descriptive Statistics and Zero-Order Correlations for Key Variables

Variable	Gender	Baseline RSA	Family support	Friend support	T1 SDQ prosocial	T1 RMET empathy	T2 SDQ prosocial	T2 RMET empathy	T2 CES civic prosocial	*M*	*SD*
Baseline RSA	−.15*	—								7.65	0.84
Family support	−.08	.12†	—							3.20	0.51
Friend support	−.26***	.13†	.72***	—						3.14	0.54
T1 SDQ general prosocial	−.21**	.01	.36***	.29***	—					1.48	0.38
T1 RMET empathy	−.04	.12†	−.10	−.04	−.12†	—				21.25	2.92
T2 SDQ general prosocial	−.23**	−.01	.36***	.32***	.48***	.02	—			1.54	0.40
T2 RMET empathy	−.04	−.08	−.09	.04	−.07	.51***	.06	—		21.35	2.50
T2 CES civic prosocial	−.29***	−.01	.25**	.35***	.30***	.10	.50***	.00	—	4.08	0.62

Note. Gender coded 0 = female, 1 = male; RSA = respiratory sinus arrhythmia; SDQ = Strengths and Difficulties Questionnaire; RMET = Reading the Mind in the Eyes Test; CES = Civic Engagement Scale; T1 = Time 1, 17 years; T2 = Time 2, 19 years.
† $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$.

19 years (Figure 1a) and tended ($p < .10$) to predict changes in general prosocial behavior from 17 to 19 years (Figure 1b). The quadratic RSA effect for cognitive empathy was further moderated by family support; therefore it is not interpreted here (see below). Examining the effect for prosocial civic behavior, the estimated peak was at RSA = 7.20. When RSA was less than 3.95, RSA at 17 years significantly and positively predicted prosocial civic behavior at 19 years. When RSA was greater than 7.74, RSA significantly and negatively predicted prosocial civic behavior. Despite a similar quadratic association of RSA with general prosocial behavior, there were no estimated points on the curve of RSA values at which there were significant positive or negative associations of RSA with general prosocial behavior, consistent with it being a weaker effect.

Hypothesis 2: Was There Evidence for Family and Friend Support Predicting Prosociality?

Two relations between family or friend support from 10 to 16 years and prosociality measures at 17 and 19 years were significant in the regression models, and another two approached significance. Receiving more family support predicted more general prosocial behavior at 17 years, and tended to predict greater increases in general prosocial behavior from 17 to 19 years. Receiving more friend support predicted more prosocial civic behavior at 19 years and tended to predict greater increases in cognitive empathy from 17 to 19 years.

Hypothesis 3: Did Family and Friend Support Moderate the Associations of RSA With Prosociality?

Across the five regression models, there were two significant interactions involving family support, one with linear RSA and one with quadratic RSA. The interaction of linear RSA × Family Support predicted general prosocial behavior at 17 years. This effect was probed by examining the association between RSA and general prosocial behavior at low (−1 *SD*), average (0 *SD*), and high (+1 *SD*) levels of family support (see Figure 2). RSA was negatively associated with Time 1 prosocial behavior at high levels of family support ($\beta = -.32$, $b = -1.77$, $p = .014$) and not significantly related to Time 1 prosocial behavior at average ($\beta = -.09$, $b = -0.48$, $p = .195$) and low levels of family support ($\beta = .15$, $b = 0.82$, $p = .293$).

The quadratic RSA × Family Support interaction predicted changes in cognitive empathy from 17 to 19 years. This was probed by examining the association between quadratic RSA and cognitive empathy at low (−1 *SD*), average (0 *SD*), and high (+1 *SD*) levels of family support (see Figure 3). Quadratic RSA was negatively associated with Time 2 cognitive empathy at high ($\beta = -.46$, $b = -26.44$, $p = .003$) and moderate ($\beta = -.18$, $b = -6.57$, $p = .007$) levels of family support, it and was not significantly associated with Time 2 cognitive empathy at low levels of family support ($\beta = .09$, $b = 3.31$, $p = .655$). At high levels of family support, the estimated peak of the inverted U-shaped curve was at the RSA value of 7.58. When RSA was less than 7.02, RSA significantly and positively predicted cognitive empathy. When RSA was greater than 7.99, RSA significantly and negatively predicted cognitive empathy. At average levels of family support, the estimated peak of the inverted U-shaped curve was at the RSA value of 7.13. When RSA was less than 5.69, RSA significantly and positively predicted cognitive

Table 2
Models Predicting General Prosocial Behavior and Cognitive Empathy at 17 Years

Predictor	SDQ general prosocial behavior				RMET cognitive empathy			
	B	*SE* (*B*)	*z*	*p*	*B*	*SE* (*B*)	*z*	*p*
Step 1								
Age at recruitment	−0.077	0.053	−1.450	.147	−0.196	0.450	−0.436	.663
Age at RSA measurement	0.121	0.064	1.905	.057†	0.399	0.555	0.719	.472
Depression risk	0.002	0.056	0.031	.975	−0.098	0.473	−0.207	.836
Gender	−0.142	0.050	−2.857	.004**	−0.155	0.421	−0.369	.712
Linear RSA	−0.320	0.358	−0.893	.372	5.985	3.074	1.621	.105
Quadratic RSA	−0.323	0.358	−0.900	.368	0.253	3.103	0.081	.935
Family support	0.259	0.068	3.814	.000***	−0.815	0.549	−1.484	.138
Friend support	−0.014	0.066	−0.217	.828	0.215	0.534	0.402	.687
Step 2								
Linear RSA × Family Support	−2.539	1.287	−1.972	.049*	4.481	11.906	0.376	.707
Linear RSA × Friend Support	1.998	1.194	1.673	.094†	1.021	10.436	0.098	.922
Quadratic RSA × Family Support	−0.565	1.332	−0.425	.671	8.376	12.332	0.679	.497
Quadratic RSA × Friend Support	1.806	1.311	1.378	.168	−8.873	11.296	−0.786	.432

Note. Gender coded 0 = female, 1 = male; depression risk coded 0 = low risk, 1 = at risk. SDQ = Strengths and Difficulties Questionnaire; RMET = Reading the Mind in the Eyes Test; *SE* = standard error; RSA = respiratory sinus arrhythmia.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

empathy. When RSA was greater than 7.59, RSA significantly and negatively predicted cognitive empathy.

Did Female and Male Youths Differ in the Associations of RSA and Support With Prosociality?

Compared to males, female Mexican-origin youths reported significantly more general prosocial behavior at 17 and 19 years and more prosocial civic behavior at 19 years. Adolescent gender was examined as a potential moderator of the associations between linear RSA, quadratic RSA, family support, and friend support and adolescents' prosocial and empathic measures at ages 17 and 19. None of the interaction terms involving gender were significant, indicating that the previously described effects were of comparable magnitude for female and male adolescents.

Discussion

Quadratic RSA predicted the development of cognitive empathy and prosocial behavior in U.S. Mexican-origin youths. Adolescents with moderate tonic RSA were likely, 2 years later, to evince greater cognitive empathy and prosocial civic behavior and marginally greater general prosocial behavior, compared to adolescents with either lower or higher RSA. These prospective effects were evident over-and-above the contributions of family and friend support, gender differences in general and civic prosocial behaviors, and the

Table 3
Models Predicting General Prosocial Behavior and Cognitive Empathy at 19 Years

Predictor	SDQ general prosocial behavior				RMET cognitive empathy			
	B	*SE* (*B*)	*z*	*p*	*B*	*SE* (*B*)	*z*	*p*
Step 1								
Age 17 score	0.403	0.076	5.308	.000***	0.427	0.057	7.475	.000***
Age at recruitment	0.027	0.059	0.453	.651	0.119	0.376	0.318	.751
Age at RSA measurement	−0.061	0.077	−0.788	.431	−0.648	0.505	−1.282	.200
Depression risk	−0.108	0.065	−1.666	.096†	−0.065	0.407	−0.161	.872
Gender	−0.124	0.056	−2.190	.029*	−0.105	0.354	−0.295	.768
Linear RSA	−0.062	0.411	−0.152	.879	−3.401	2.569	−1.324	.196
Quadratic RSA	−0.655	0.391	−1.674	.094†	−6.008	2.479	−2.424	.015*
Family support	0.138	0.079	1.747	.081†	−0.635	0.480	−1.322	.186
Friend support	0.036	0.076	0.492	.623	0.770	0.463	1.664	.096†
Step 2								
Linear RSA × Family Support	1.181	1.503	0.786	.432	12.245	9.453	1.295	.195
Linear RSA × Friend Support	−0.583	1.427	−0.409	.683	−17.008	9.188	−1.851	.064†
Quadratic RSA × Family Support	−1.303	1.445	−0.902	.367	−19.303	9.172	−2.106	.035*
Quadratic RSA × Friend Support	2.388	1.502	1.590	.112	8.544	10.399	0.822	.411

Note. Age 17 score corresponds to Time 1 prosocial behavior or Time 1 cognitive empathy. Gender coded 0 = female, 1 = male; depression Risk coded 0 = low risk, 1 = at risk. SDQ = Strengths and Difficulties Questionnaire; RMET = Reading the Mind in the Eyes Test; *SE* = standard error; RSA = respiratory sinus arrhythmia.
$^{\dagger}p < .10$. $^{*}p < .05$. $^{***}p < .001$.

Table 4
Model Predicting Prosocial Civic Behavior at 19 Years

Predictor	CES prosocial civic behavior			
	B	*SE* (*B*)	*z*	*p*
Step 1				
Age at recruitment	0.099	0.097	1.014	.310
Age at RSA measurement	−0.068	0.127	−0.532	.595
Depression risk	−0.080	0.107	−0.749	.454
Gender	−0.241	0.094	−2.568	.010**
Linear RSA	−0.679	0.643	−1.056	.291
Quadratic RSA	−1.539	0.617	−2.496	.013*
Family support	0.007	0.132	0.052	.958
Friend support	0.345	0.126	2.733	.006**
Step 2				
Linear RSA × Family Support	−1.590	2.370	−0.671	.502
Linear RSA × Friend Support	1.670	2.245	0.744	.457
Quadratic RSA × Family Support	0.901	2.315	0.389	.697
Quadratic RSA × Friend Support	0.498	2.388	0.209	.835

Note. Gender coded 0 = female, 1 = male; depression risk coded 0 = low risk, 1 = at risk. CES = Civic Engagement Scale; *SE* = standard error; RSA = respiratory sinus arrhythmia.
* $p < .05$. ** $p < .01$.

stability of cognitive empathy and general prosocial behavior. Furthermore, the quadratic association of baseline RSA at 17 years with the development of cognitive empathy from 17 to 19 years was stronger for youths with more supportive family relationships. There was only one linear association between RSA and U.S. Mexican-origin adolescents' prosociality, a concurrent negative association between RSA and general prosocial behavior at 17 years in the context of having greater family support. These findings strengthen the growing body of evidence showing that having moderate baseline PNS activity may confer regulatory advantages that support prosocial development (Acland et al., 2019; Clark et al., 2016; Kogan et al., 2014; Miller et al., 2017; R. Zhang & Wang, 2019, 2020) and replicate studies showing that youths are more likely to be empathic and prosocial when they are in supportive relationships (Boele et al., 2019; Carlo et al., 2022; Hastings et al., 2015).

Although greater baseline PNS activity, as reflected by higher RSA, has been posited as a physiological resource supporting greater capacity for emotional self-regulation (Beauchaine & Thayer, 2015) and social engagement (Porges, 2011), higher RSA has not been consistently linked with greater prosocial responding (Hastings & Miller, 2014). Individuals with tonically elevated parasympathetic down-regulation may require stronger stimuli for triggering empathic motivation for prosociality than is conveyed through sad facial expressions or other relatively mild cues of need by others (Hastings et al., 2000, 2006; Miller & Hastings, 2016). Whereas individuals with higher baseline RSA may have higher thresholds for noticing and engaging with the emotions of others, those with lower baseline RSA may too readily experience strong vicarious arousal that could trigger personal distress responses (Eisenberg, 2000). Hence, being parasympathetically prepared to engage with the social world with a balance of attentiveness and regulation may place children, adolescents, and adults with moderate baseline PNS activity at the "sweet spot" of readiness to be empathic, prosocial, and interpersonally responsible.

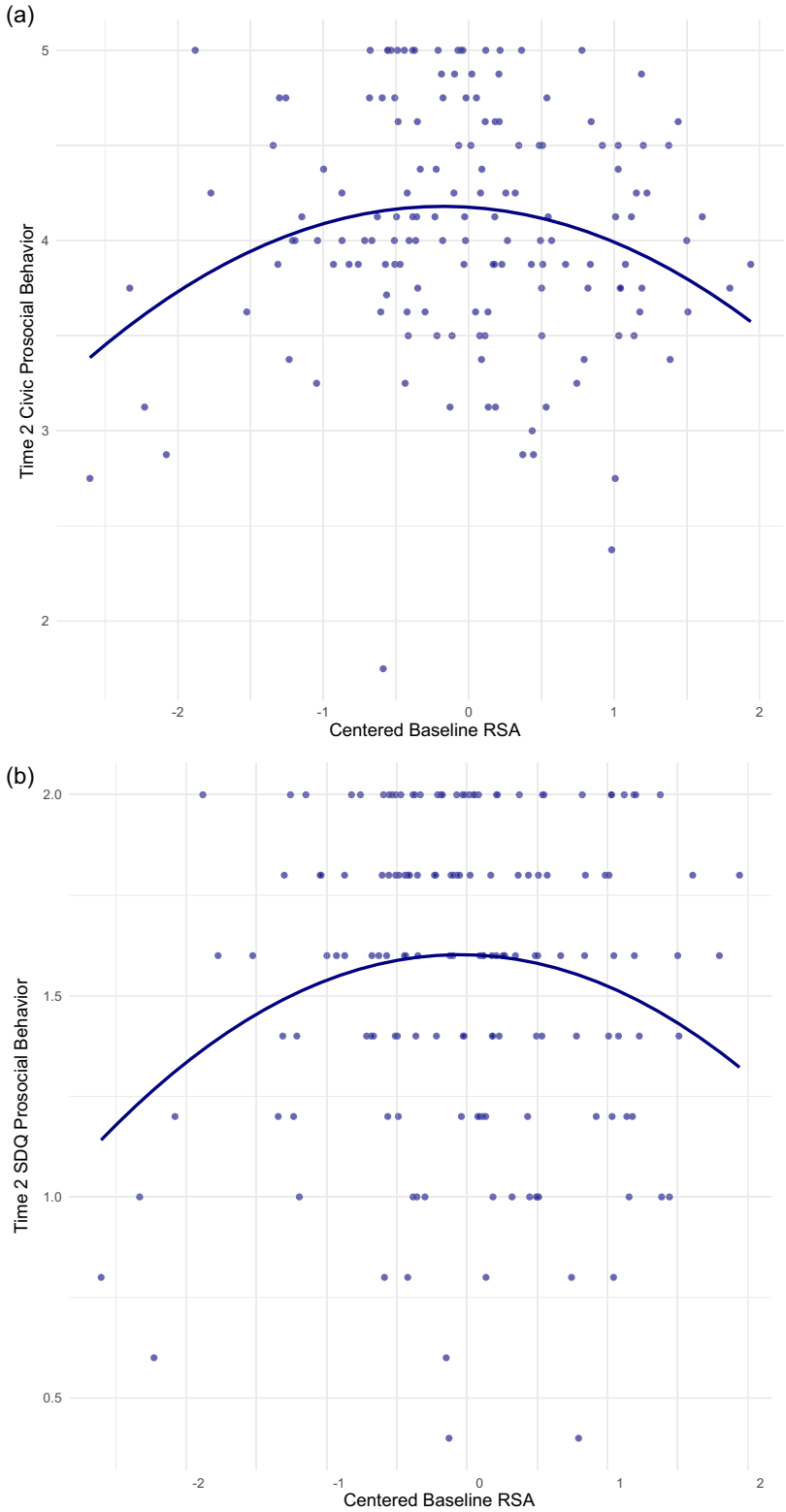
It is striking that our three observations of this biobehavioral pattern were in the prospective associations of adolescents' earlier moderate baseline RSA with cognitive empathy, general prosocial behavior, and prosocial civic behavior 2 years later, rather than concurrent cognitive empathy and prosocial behavior. The RMET test of cognitive empathy calls upon fairly advanced vocabulary for emotion terms as well as perceptual accuracy in recognizing affective cues (Dodell-Feder et al., 2020), such that the further education and interpersonal experience obtained from late adolescence into emerging adulthood may have been necessary for youths with moderate baseline RSA to be able to express their empathic capacities on this measure. Family support from 10 to 16 years was strongly predictive of general prosocial behavior at 17 years, reports of which were fairly high ($M = 1.48$ on a scale from 0 to 2); yet, youths reported significantly more prosocial behavior at 19 years than at 17 years. Hence, having moderate baseline RSA at 17 years appeared to position youths to make modest advances upon already strong tendencies to be prosocial. Prosocial civic behavior was not measured at the same assessment as baseline RSA, so we cannot know whether that quadratic association may have been evident concurrently. However, the community-oriented items of the CES call upon personal agency as well as opportunity for social engagement outside the home, peer, and school contexts (C. A. Flanagan et al., 2007); both agency and opportunity could be expected to be greater when youths were 19 years old than when they were 17 years old. Hence, adolescents with moderate RSA may have been primed to express their prosociality when they matured to the point that this broader social venue was more available to them. Of course, many youths engage in volunteering and positive community-oriented activities across adolescence (McGinley et al., 2010; Wray-Lake & Shubert, 2019), so this biobehavioral aspect of prosociality should be tested at younger ages.

The prospective quadratic link between baseline RSA and cognitive empathy was strongest for U.S. Mexican-origin youths who had received more family support consistently across early and middle adolescence, compared to youths in less supportive families. Conversely, in the context of less family support, baseline RSA at 17 years was unrelated to later RMET scores. Prior work has shown that nurturing, warm, and involved parenting interacts with baseline and reactive PNS activity to predict prosocial behavior in children (Miller et al., 2020; Miller & Hastings, 2016) and adolescents (Cui et al., 2019). In experiencing more support from family members, adolescents could have seen that others noticed and attended to their own emotional cues and needs, which may have served as models or learning experiences for youths to orient to the emotions of others. Those adolescents who were parasympathetically primed to be attentive to but not overwhelmed by others' emotions—that is, adolescents with moderate RSA—may have been primed to internalize and express this emotional attentiveness (Miller & Hastings, 2016, 2020), in accord with goodness-of-fit models of development (Wachs & Gandour, 1983).

It is worth noting that prior studies have shown that moderate baseline RSA appears to confer benefits for other aspects of functioning as well. Compared to those with lower or higher baseline RSA, preschoolers with moderate RSA are less likely to develop internalizing and externalizing problems in childhood (Ugarte et al., 2021), and adults with moderate RSA feel safer and more content (Duarte & Pinto-Gouveia, 2017), have fewer negative emotions (Gray & Tully, 2020), report greater life satisfaction and

Figure 1

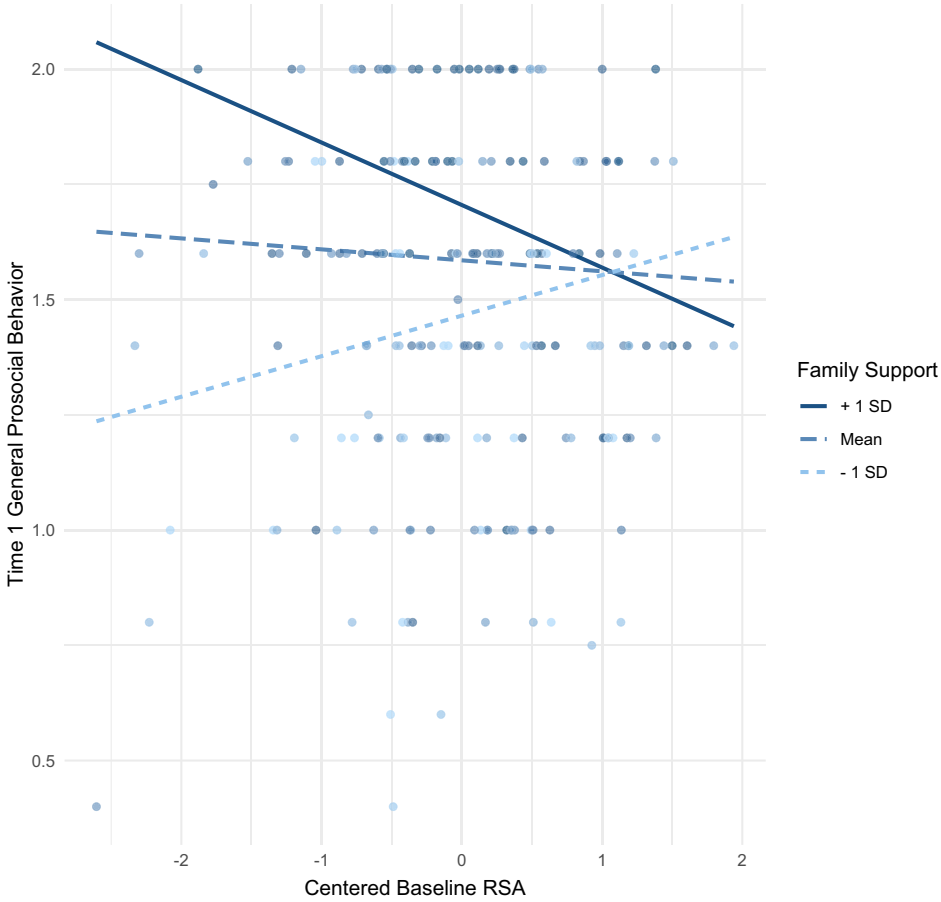
Quadratic Associations of Baseline RSA With Prosocial Behavior



Note. Moderate baseline RSA at 17 years predicted more prosocial civic behavior (Figure 1a) and tended to predict more general prosocial behavior (Figure 1b) at 19 years, compared to lower or higher baseline RSA, in accord with a quadratic function (inverted U-shaped curve). RSA = respiratory sinus arrhythmia; SDQ = Strengths and Difficulties Questionnaire. See the online article for the color version of this figure.

Figure 2

Family Support Moderated the Concurrent Association of Linear Baseline RSA With General Prosocial Behavior at 17 Years



Note. RSA = respiratory sinus arrhythmia. See the online article for the color version of this figure.

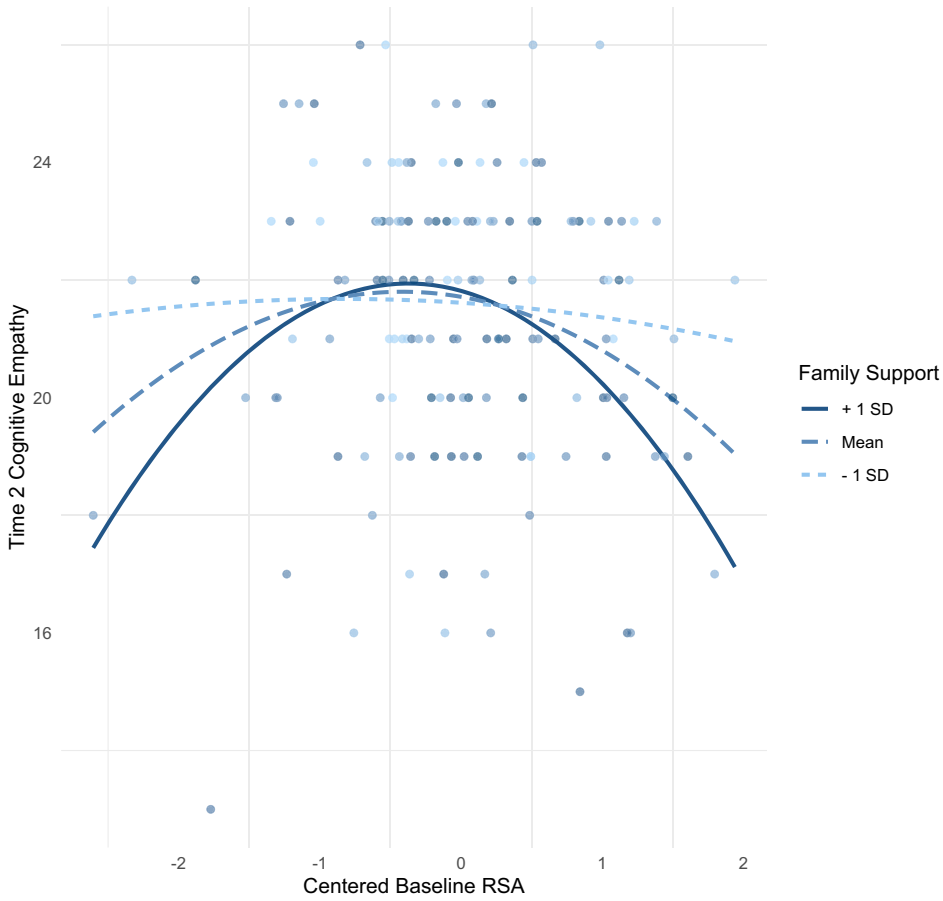
less depression (Kogan et al., 2013), and perform better on tests of executive function (Spangler et al., 2015). Furthermore, moderate baseline RSA appears to buffer children against increases in emotional and behavioral problems when parents are more critical and rejecting, associations that are evident at both lower and higher RSA (Ugarte et al., 2021). Hence, moderate baseline RSA may reveal an effective balance of internal regulatory capacities with attentiveness to the social and emotional cues of others, a balance that serves to support adaptive functioning broadly and to prepare children and youths to be receptive toward positive socialization influences while protected from aversive ones.

Although the association of quadratic RSA with later cognitive empathy was not significant at low levels of family support, Figure 3 suggests that it was in the context of having experienced less family support that youths with either lower or higher baseline RSA were likely to perform better on the RMET. This was somewhat unexpected. Some prior theory and research has suggested that features of prosociality may be particularly important assets to develop when raised in contexts of environmental risk (Piff et al., 2010), akin to the hidden talents hypothesis (Ellis et al., 2022). It is uncertain why cognitive empathy, in particular, would be strengthened in late adolescence for youths with more extreme baseline RSA and less supportive families. However, this could be an intriguing question to pursue in future research.

Counter to our expectations, the highest level of general prosocial behavior at 17 years was projected to be for youths with both lower baseline RSA and more family support. Although surprising, this finding could suggest that youths who were physiologically primed to be most sensitive to others' social and emotional cues were most receptive to this socializing influence. Some prior studies have similarly shown parental factors to predict various aspects of functioning more strongly for children with lower baseline RSA (i.e., Hastings, Kahle, et al., 2014; Skibo et al., 2020). Parent and family support functions as a model for helping others, provides an external support for regulation when potential stressors occur, and bolsters adolescents' emotion regulation abilities (Hastings et al., 2015; Morris et al., 2017; Van Lissa et al., 2019). Thus, U.S. Mexican-origin youths with lower baseline RSA and more supportive families may have been both likely to notice others' need for assistance and able to feel secure in providing that assistance. An alternate implication of the finding depicted in Figure 2, however, arises from the "empathy as a risky strength" literature (Tone & Tully, 2014). The emotional sensitivity of youths with low baseline

Figure 3

Family Support Moderated the Prospective Association of Quadratic Baseline RSA With Cognitive Empathy at 19 Years



Note. RSA = respiratory sinus arrhythmia. See the online article for the color version of this figure.

RSA may contribute to them being overinvested in pleasing others, which could be exacerbated in a close-knit family. Both Latinx and White youths report heightened stress when they feel that making positive contributions to the family is obligatory rather than voluntary (Fuligni et al., 2009; Levine et al., 2017). This reaction might be most likely for youths with lower baseline RSA, given a more limited parasympathetic capacity to support emotional self-regulation. We must note, however, that as we had not posed any a priori hypotheses regarding interactions of linear RSA and supportive relationships predicting prosociality, these post hoc interpretations should be considered with caution.

In addition to the findings involving RSA, U.S. Mexican-origin youths with more supportive families across adolescence reported more general prosocial behavior at 17 years, whereas those with more friend support reported more prosocial civic behavior at 19 years. These findings were consistent with the literature on the potential benefits of supportive relationships for prosocial development (Hastings et al., 2015; Hastings, McShane, et al., 2007; Putnick et al., 2018), including for U.S. Mexican-origin and other Latinx adolescents (Carlo et al., 2011; Carlo, Streit, et al., 2018; Carlo, White, et al., 2018). Considering family support, we (Carlo et al., 2022) and others (Causadias et al., 2017; Michalska & Davis, 2019) have advocated for greater recognition and incorporation of culturally informed perspectives within biopsychosocial models of developmental science. Although we did not include specific cultural values within these analyses, family support mirrors aspects of familismo (closeness, identification, and loyalty within the nuclear family), a core traditional value of many Latinx cultures (Carlo & de Guzman, 2009). Within prior studies of adolescent development in Latinx samples, both parent familismo and parent support have been found to predict both youths' endorsement of culturally traditional values and their prosocial behavior (Carlo et al., 2022). Affiliative relationships and positive social engagement can be seen as aligned with Latinx cultural values and ethnic identity, such that supportive family relationships may be salient for U.S. Mexican-origin adolescents to behave in prosocial ways with their social partners (family, friends, and peers). Taken together, the present findings are in accord with the central role of family relationships and cultural values in Mexican-heritage families (Carlo et al., 2022) and demonstrate that the effects of physiological mechanisms on prosocial development in U.S. Mexican-origin youths can vary as a function of level of family support.

The unique benefit of having supportive friendships was evident for emerging adults' engagement in broader community-oriented prosocial behaviors. This finding suggests that feeling secure and connected with extrafamilial close others (i.e., friends) may be particularly important for scaffolding U.S. Mexican-origin youths' preparedness for engaging positively with the broader community as they approach the transition into adulthood. Indeed, prior work has shown that adolescents with closer friendships and more peer engagement report stronger feelings of responsibility toward their community and more engagement in civic activities (Wray-Lake et al., 2016; Zaff et al., 2008) and are more likely to engage in volunteerism in adulthood (Zaff et al., 2003). Conversely, we did not find the predicted moderating influence of friend support on relations between RSA and prosociality. Although Y. Zhang et al. (2020) found that peer attachment predicted prosocial behavior for college-aged adults with lower RSA, examinations of two-way interactions between peer influences and PNS regulation predicting various adolescent behaviors have been largely nonsignificant (McQuade et al., 2019; Perry et al., 2023). As familial relationships are contexts that act on development from infancy onward, and are more stable than friendships, it is plausible that family support would be the stronger influence on adolescents' phenotypic expression of their physiological capacities for prosociality. However, there has been far less developmental research on friend or peer relationship qualities interacting with physiology than there has been for parent and family relationship qualities (Murray-Close, 2013), such that it would be premature to make firm conclusions. Further biopsychosocial research with peers and friends is sorely needed.

While recognizing the strengths and contributions of this research, it is also necessary to take note of some limitations in the study. (a) Although cognitive empathy was assessed with a behavioral task, the RMET evidenced weak internal consistency despite high test–retest stability, which may be indicative of a multidimensional structure underlying RMET scores (Olderbak et al., 2015). Despite considerable evidence for the validity of the RMET (Pavlova & Sokolov, 2022), there also is evidence that it may incorporate biases favoring European–American and western European peoples of more advantaged socioeconomic status (Dodell-Feder et al., 2020), suggesting that it may have produced underestimations of cognitive empathy in the current sample. Efforts to replicate our findings with other measures of cognitive empathy would be warranted. (b) The PNS is just one of the many neurobiological regulatory systems that contribute to prosociality (Hastings, Miller, et al., 2014), and nonlinear patterns of dynamic PNS reactivity also have been associated with prosociality (Cui et al., 2015; Miller et al., 2015, 2016, 2020); it would be valuable for future research to consider how baseline and reactive activity across multiple systems is supportive of the capacities to experience and express positive regard for the well-being of others. (c) As family and friend support were assessed prior to RSA and prosociality, these analyses cannot speak to whether levels of support from 10 to 16 years were maintained over the transition to emerging adulthood. (d) The study was not experimental, such that despite the longitudinal design with repeated measures of several variables, it is not possible to draw causal inferences about the relations between RSA, support, and prosociality. (e) Although many of the findings were convergent with prior studies conducted with samples drawn from multiple nationalities and ages, what was observed with this sample of U.S. Mexican-origin youths with moderately elevated depressive problems living in Northern California should not be assumed to generalize to other Latinx communities.

In conclusion, this study made several important contributions to our understanding of adolescent prosocial development. By testing for concurrent and prospective quadratic associations between baseline PNS activity and multiple aspects of prosociality within the contexts of family and friend relationships in a sample of U.S. Mexican-origin adolescents, the extant literature has been extended in many ways. Yet, the extent to which the findings were largely consistent with what has been observed at different ages and in samples across ethnic/racial communities points toward some broadly shared properties or principles with regard to prosocial development. Like children, adults, and adolescents in other cultural communities, Mexican-origin adolescents are most likely to be attentive and positively responsive toward the needs of others when they have both the physiological capacity to engage prosocially and the experience of supportive relationships that scaffold and reinforce prosociality. Given the scarce existing longitudinal work that directly examines the interplay of physiological and socialization mechanisms, it is possible that the joint effects of RSA and family support are uniquely linked to prosociality in U.S. Mexican youth. Continuing to conduct biopsychosocial developmental examinations of the myriad additive and multiplicative ways in which these internal and external resources converge to promote trajectories of prosocial development within and across cultures will be important for informing efforts to enhance youths' abilities to become compassionate, helpful, and civically engaged adults.

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