

Prenatal Stress and Infant Regulatory Capacity

By

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ABSTRACT

The development of self-regulation is believed to play a crucial role in predicting later psychopathology and is believed to begin in early childhood. The early postpartum period is particularly important in laying the groundwork for later self-regulation as infants' dispositional traits interact with caregivers' co-regulatory behaviors to produce the earliest forms of self-regulation. Moreover, although emerging literature suggests that infants' exposure to maternal stress even before birth may be integral in determining children's self-regulatory capacities, the complex pathways that characterize these developmental processes remain unclear. The current study considers the complex, transactional processes in a high-risk, Mexican American sample. Data were collected from 305 Mexican American infants and their mothers during prenatal, 6- and 12-week home interviews. Mother self-reports of stress were obtained prenatally between 34-37 weeks gestation. Mother reports of infant temperamental negativity and surgency were obtained at 6-weeks as were observed global ratings of maternal sensitivity during a structured peek-a-boo task. Microcoded ratings of infants' engagement orienting and self-comforting behaviors were obtained during the 12-week peek-a-boo task. Study findings suggest that self-comforting and orienting behaviors help to modulate infants' experiences of distress, and also that prenatal stress influences infants' engagement in each of those regulatory behaviors, both directly by influence tendencies to engage in orienting behaviors and indirectly by programming higher levels of infant negativity and surgency, both of which may confer risk for later regulatory disadvantage. Advancing our understandings about the nature of these developmental pathways could have significant implications for targets of early intervention in this high-risk population.

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Although there is no one prototypical definition of self-regulation, research appears to converge on the notion that self-regulation involves both the deliberate and automatic modulation of emotional, behavioral and attentional reactions (Brownell & Kopp, 2007; Karoly, 1993; Rothbart, Ellis, & Posner, 2011). Insofar as self-regulation dictates internally and externally mediated responding, it's not surprising that the study of self-regulation has been regarded as "the single most crucial goal for advancing an understanding of development and psychopathology" (Posner & Rothbart, 2000, p. 427). Indeed, regulatory behaviors emerging in infancy have been linked to children's social skills, academic competence, behavior problems, and even psychopathology in adulthood (Althoff, Verhulst, Rettew, Hudziak, & van der Ende, 2010; Eisenberg, Liew, & Pidada, 2004; Eisenberg et al., 2009). Although some controversy surrounds the question of when purposeful self-regulation begins, infants are believed to come into the world with initial regulated states (Sander, 1977) as well as "mechanisms for both self-soothing and enlisting the soothing of others" (Rothbart, 2011, p. 93). Over the course of the next few years of life, this dispositional regulation continues to evolve as it interacts with external sources of regulation, especially caregiver co-regulatory functions, to produce the earliest forms of self-regulation (Calkins, 1994). Although research has predominantly focused on the importance of children's environmental and experiential factors in the postnatal period, an emerging literature suggests that the significance of such environmental influences may actually be traced back to as early as the prenatal period.

Pregnancy represents a vulnerable time both for mothers and for their developing fetuses. During this time, women are particularly susceptible to stress, anxiety, and depression given the number of major physical, emotional, social, and practical life

changes they face. In fact, as many as 60% of pregnant women have reported increases in negative mood and anxiety symptoms (Faisal-Cury & Menezes, 2007). These stressful experiences have obvious negative implications for mothers' psychological well-being (Heron, O'Connor, Evans, Golding, & Glover, 2004), but may further impact fetal development in-utero both indirectly by interfering with maternal self-care and directly by disrupting internal physiological systems (Lazinski, Shea, & Steiner, 2008). Indeed, infants prenatally exposed to stress are likely to evidence more physiological dysregulation, less attentiveness, and more distressed behaviors (Gutteling et al., 2005; Anja C. Huizink, Robles de Medina, Mulder, Visser, & Buitelaar, 2002). Given the breadth of factors to which regulatory skills can be attributed, the question emerges as to the extent to which prenatal stress exerts a direct effect on infant regulatory capacity or is mediated by the interplay between infant temperamental characteristics and ongoing caregiver-infant interactions.

Finally, whereas self-regulation is now widely accepted as a precursor for later positive and negative adjustment, relatively few studies have gone on to extend understandings about the development of self-regulation to higher-risk samples. Specifically, although Mexican Americans are at greater risk for poorer academic achievement, emotional problems, engagement in risky sexual and other antisocial behaviors, health problems, and involvement in the criminal justice system compared to their Caucasian counterparts (Cauce, Cruz, Corona, & Conger, 2011), little is known about processes influencing socioemotional development in Mexican American children (Carlo & de Guzman, 2009). Moreover, although Mexican American mothers are believed to experience disproportionately higher rates of prenatal distress (Gress-Smith,

Luecken, Lemery-Chalfant, & Howe, 2012), few or no studies have investigated whether these experiences of maternal prenatal stress may have negative cascading influences on children's socioemotional development in Mexican American samples. The current study addresses these critical questions in a sample of high-risk, Mexican American mothers and their infants.

Regulatory Behaviors in Infancy

Calkins and Fox have argued that the period from infancy to toddlerhood is a crucial period for the development of self-regulation (Calkins, 1994; Fox & Calkins, 1993), during which time infant dispositional characteristics interact with caregiver characteristics to produce the earliest forms of self-regulation (Beauchaine, 2001). From birth, infants evidence rhythmic differences in what Sander 1977) terms *initial regulation*, or regulation of infant states including sleep, hunger, and elimination cycles as well as states involving affect and attention. In fact, infants are believed to experience more sleep and wake cycles than at any other point in their lives (Korner, 1972), the regularity of which may be related to later child negativity and attentional control (Canals, Hernández-Martínez, & Fernández-Ballart, 2011). The regularity of infants states is largely influenced by infant dispositional characteristics, with some infants more able to self-regulate in the face of distress and others relying more on external sources of soothing from caregivers (Rothbart, 2011). Furthermore, because young infants have relatively little control over structuring their environments, caregivers' responsivity to infant cues plays an important role in modulating these infant states and setting the stage for infant-regulated cycles.

Some evidence exists to suggest that caregiver responsiveness to infant cues may impact the regularity of infant states as early as the first ten days postpartum. In a study contrasting newborns receiving regular but regimented caregiving with routine feeding, diaper changing, and caregiving as compared to newborns receiving responsive care with caregivers responding to infant needs on an individual basis, Sander and colleagues (1972) found that infants with responsive caregivers developed more stable sleeping and feeding schedules compared to their routinely cared-for counterparts. Further, those differences persisted through the second postpartum month. Over the course of the next few months, infant dispositional characteristics continue to interact with caregiver characteristics in a dance Tronick and Kopp call *mutual regulation* that defines the stability of infant states and produces the earliest forms of child self-regulation (Kopp, 1982; E. Z. Tronick, 1982).

Although some controversy exists as to when children are first capable of purposeful self-regulation, behaviors such as orienting and, to some extent, self-comforting are thought to serve regulatory functions beginning in early infancy (Rothbart & Derryberry, 1981; Rothbart, Ziaie, & O'Boyle, 1992). *Orienting*, or direction of attention towards or away from distressing objects in the environment, is considered fundamental to the development of self-regulation (Ruff & Rothbart, 1996) and appears to play a role in the regulation of distress beginning from early infancy. In and of itself, orienting can be a very powerful regulatory mechanism by serving as a perceptive filter that either focuses on or ignores distressing objects in the environment (Ruff & Rothbart, 1996). In fact, Field (1981) has found that four-month-old infants actually experience reductions in physiological reactivity (heart rate) after looking away from distressing objects.

Orienting is present from birth in its most primitive form and manifests as preferential orienting that preemptively modulates arousal. In a study examining orienting in newborn infants between 11 and 48 hours old, Lewkowicz and Turkewitz (1981) found that infants who were already aroused tended to engage in preferential orienting towards lower-intensity stimuli that would not further contribute to their levels of arousal compared to their non-aroused counterparts when both low and high intensity visual stimuli were present. Over the course of the next several months, infants continue to gain increasing mastery over their capacities to shift attention from one visual location to another (Johnson, Posner, & Rothbart, 1991; Posner & Petersen, 1990) and begin more and more to engage in active attention regulation strategies (Rothbart, et al., 1992). Further, infants who can more readily disengage gaze from distressing objects are less susceptible to negative affect and are easier to soothe (Crockenberg & Leerkes, 2004; Harman, Rothbart, & Posner, 1997; Johnson, et al., 1991). Orienting behaviors represent an important regulatory strategy across the first year of life, and a child's mastery over these orienting behaviors sets the stage for later self-regulatory efficacy. In fact, control over orienting behaviors across the first year of life has been found to predict child effortful control at 18 months (Bridgett et al., 2011), effective emotion regulation at 24 months (Morales, Mundy, Crowson, Neal, & Delgado, 2005), and reduced aggression at 30 months (Crockenberg, Leerkes, & J6, 2008).

Another set of important regulatory strategies observed in infancy are *self-comforting behaviors*—“behaviors that resemble calming” such as thumb-sucking, face rubbing, and self-clasping (Crockenberg & Leerkes, 2004, p. 1126). Self-comforting behaviors appear to represent a more rudimentary regulatory behavior available from

birth (Rothbart, 2011). In fact, self-soothing behaviors like thumb-sucking have been observed even before birth in-utero, and some infants have even been born sucking their thumbs (Rothbart, 2011). Self-comforting behaviors occur with highest peak frequency during the first 3 months of life, and then appear to wax and wane with a roughly downhill trend as infants begin to adopt more complex regulatory behaviors like orienting away from distressing stimuli (Rothbart, et al., 1992). Further, recent efforts to corroborate the regulatory function of self-comforting behaviors have found that they are associated with reductions in infant distress in 6- and 10-month-olds (Crockenberg & Leerkes, 2004; Stifter & Braungart, 1995), and also that oral-self and oral-other behaviors effectively buffer against physiological and motoric arousal (Field, 1999; Liaw et al., 2010). Although self-comforting behaviors may not play an enduring role in the emergence of child later self-regulatory behaviors, because they occur with such great prevalence in the early postpartum period, they represent an important set of regulatory behaviors employed in infancy.

Contributions of Infant Temperament

Temperament reflects the constitutional differences in emotional, motor, and attentional reactivity to change as well as the regulation of this reactivity, and is believed to serve as a basis for children's later self-regulatory functioning (Rothbart, 2011). In fact, Feldman (1999) has argued that the development of self-regulation can only be understood when infant temperament is considered, and Belsky (1997) has suggested that temperament can affect child outcomes both directly, by influencing the child's self-regulatory capacity, and interactively by influencing the nature of the parent-child relationship.

According to Rothbart and Gartstein (2003), infant temperament is comprised of three broad constructs: surgency, negativity and orienting/ regulation, with surgency and negativity representing positive and negativity reactivity, respectively. Orienting/ regulation captures infant sustained attention and overall soothability and represents the fundamental basis upon which self-regulation is construed. To the extent that orienting/ regulation may essentially be non-distinguishable from regulatory capacity in the early postpartum period, the current study focused instead on the reactive components of temperament.

Negativity encompasses general negative mood, fear, and anger responses, and is thought to presuppose risk both by implicating the relative frequency of the infant's distress response and by creating more opportunities for negative responding by others (Belsky, 1997). Accordingly, negativity has been regarded as one of the key characteristic of infants labeled as having "difficult" temperament styles (Thomas & Chess, 1977). Gunnar and colleagues (Gunnar, Brodersen, Nachmias, Buss, & Rigatuso, 1996) have suggested that highly negative children are particularly likely to perceive neutral events as threatening, and thus may constantly experience heightened levels of emotional arousal requiring modulation. However, these heightened levels of arousal may actually interfere with children's capacities to engage in effective self-regulatory strategies. Santucci (2008) and colleagues found that children with higher negativity were more likely to employ maladaptive regulatory strategies including emotional displays of sadness and anger, and were more likely to fixate attention on the frustrating objects. Similarly, Calkins and colleagues (2002) found that 6-month-old infants who were more easily frustrated were less likely to refocus attention onto less-distressing objects and

more likely to kick and bang. Surprisingly, these infants were also more likely to seek help from their mothers, a finding Calkins and colleagues hypothesized might reflect highly negative infants' increased dependence on their mothers to help regulate because their own regulatory strategies were ineffective. To the extent that infants with high levels of negativity may experience more distress, engage in less effective regulatory strategies and rely more on external sources of regulation, temperamental negativity may represent a risk factor for emerging regulation.

Infant *surgency* includes components of both positive affectivity and high activity level, and has been implicated both as a risk and protective factor for emerging regulation. Whereas some studies have suggested that the high levels of intensity associated with surgency may exaggerate the expression of negativity (Rothbart, Derryberry, & Hershey, 2000), others suggest that the positive affectivity associated with surgency may serve a protective function by promoting positive infant-caregiver interactions that facilitate caregiver responsiveness (Molfese et al., 2010). Perhaps again related to relatively heightened levels of arousal associated with high activity level, highly active infants are less likely to engage in oral-self behaviors (Escalona, 1969; Rothbart, et al., 1992) and are more likely to be easily frustrated (Calkins, et al., 2002). Contrastingly, Gartstein and colleagues found that mother reports of infant surgency during the first year of life predicted child increased effortful control, a component of self-regulation, in preschool (2009). Finally, Rothbart and Gartstein (2003) have found that higher levels of surgency are related to higher levels of orienting/ regulation. However, to the extent that the number of studies examining contributions of surgency to emerging regulation is limited, connections between the two remain to be clarified.

Maternal Sensitivity, Infant Temperament, and Infant Regulatory Capacity

Caregivers are important constituents of infants' early interactional experiences and many studies have documented the importance of different caregiver characteristics to infant outcomes. One particular caregiver characteristic that has frequently been identified as an important predictor of emerging regulation is caregiver sensitivity. *Sensitivity* has been defined as the caregiver's availability, attentiveness, and responsiveness to infant cues according to the infant's age appropriate growth needs (Ainsworth, Blehar, Waters, & Wall, 1978). When infants are young, caregivers play a central role in structuring infant feeding, sleeping, and other routines, and caregiver responsiveness to infant cues during this time predicts infant later state regulation (Sander, et al., 1972). As infants begin to engage more in mutual interactions such as face-to-face play, caregivers continue to regulate infant responses by "initiating and maintaining the infant's interest, modulating the infant's affective responses, and responding to the infant's signals" (Poehlmann et al., 2011, p. 178).

During these face-to-face interactions, sensitive caregivers may reduce the impact of infant physiological arousal on infant regulation by recognizing infant distress cues and responding accordingly (e.g., by soothing the infant). In a study examining infant cortisol reactivity and regulation in response to a mild stressor (i.e., routine bathing with their mothers) in three-month-old infants, Albers and colleagues (2008) reported that infants showed increases in cortisol levels during bathing but that infants with sensitive mothers were able to recover more quickly. Similarly, Gunnar and colleagues (1992) found that 9-month-old infants provided with sensitive, responsive babysitters during mother separation episodes experienced fewer increases in cortisol reactivity compared to

infants whose babysitters ignored them unless they cried. It appears that caregiver sensitivity to infant cues may be powerful enough to affect infants' affective states within isolated episodes of heightened infant reactivity.

Over time and across many interactions, the consistency with which sensitive caregiving effectively modulates infant physiological reactivity may begin to re-program infants' physiological stress response in a way that reduces infants' overall experiences of distress (Gunnar & Donzella, 2002). In fact, caregiver sensitivity has even been found to predict reductions in the reactivity associated with infant temperamental negativity over time. In a study examining the trajectory of temperamental negativity from 4 to 16 months, Braungart-Rieker and colleagues (2010) found that although infant temperamental negativity was related to increasing levels of negativity during frustration tasks, infants whose mothers were rated as more sensitive showed slower increases in negativity over time. Furthermore, the effects of maternal sensitivity on child negativity may even extend into early adolescence. In a study that followed 36 parent-child dyads from 3 months to 13 years, Feldman (2010) found that children who consistently received lower levels of maternal sensitivity across each of six time points from 3 months to 13 years were more likely to report higher levels of emotional and behavioral disturbance at 13 years.

Finally, sensitive caregivers may promote regulatory functioning by supporting infants' capacities to engage in effective regulatory behaviors. In fact, Feldman and colleagues (2011) found that two- to three-year old children whose mothers were more sensitive tended to engage in more mature regulatory strategies such as distraction and attentional manipulation during frustration tasks. Contrastingly, Belsky and colleagues

(2007) have suggested that caregiver insensitive interactions may undermine infants' development of attentional control. For example during face-to-face interactions, infants who are overstimulated from play with mom may attempt to avert gaze to reduce physiological arousal. Whereas sensitive mothers might pick up on such infant cues by waiting for the infant to re-initiate engagement before resuming play, insensitive mothers might force infants to re-engage immediately by moving into the infant's line of vision and thereby interfere with the infant's capacity to effectively modulate arousal. Indeed, higher levels of maternal sensitivity have been found to predict higher levels of attention regulation at different points from 5 months (Conradt & Ablow, 2010) to 9 years of age (Belsky, et al., 2007).

Prenatal Stress and Infant Regulatory Capacity

While much of the extant research has focused on postnatal contributions to infant regulation, emerging literature suggests factors affecting infant regulation may be traced back to as early as the prenatal period. Maternal prenatal stress may affect the development of infant regulatory systems both indirectly by impacting infant physical development and directly by disrupting internal physiological systems (Lazinski, et al., 2008). Infants exposed to stress in utero tend to have earlier births, more birth complications, lower birth weights and smaller head circumferences (Rice et al., 2010), adverse birth outcomes further believed to confer risk for later state (Feldman, 2006), affect (Hsu & Jeng, 2008), and attention regulation (Anja C. Huizink, et al., 2002). Additionally, the physiological dysregulation associated with prenatal stress may more directly impact infant regulatory functioning by interfering with the normal development of the infants' stress response system (i.e., the Hypothalamic – Pituitary – Adrenal, HPA

axis) (Meaney, 2001), which then impairs infants' later capacities for emotional and behavioral regulation. Indeed, mother self-reports of stress, anxiety and depression during pregnancy have been linked to child negative mood, oppositional, aggressive and hyperactive behavior problems at child ages two, four and six years even after controlling for infant birth outcomes, socioeconomic disadvantage, maternal postnatal anxiety and depression (Gutteling, et al., 2005; O'Connor, Heron, Golding, & Glover, 2003).

Infants of prenatally stressed mothers are more likely to evidence dysregulated infant states, heightened physiological arousal, reduced attentional control, and extreme distress responses (O'Connor et al., 2007; O'Connor, Heron, Golding, Beveridge, & Glover, 2002). Based on a sample of over 14,000 children, findings from the Avon Longitudinal Study of Parents and Children indicated that maternal prenatal anxiety and depression were related to infant sleep problems at 18 and 30 months even after controlling for the ratio of birth weight to gestational age, psychosocial risks, and maternal postnatal anxiety and depression (O'Connor, et al., 2007). Similarly, data from the Helenski longitudinal temperament project suggested that mother self-reports of psychological distress during pregnancy predicted infant irregular sleep-wake, feeding, and elimination patterns at six months, and further that initial state dysregulation predicted later social inhibition and negative emotionality at child age five years (Martin, Noyes, Wisenbaker, & Huttunen, 1999). This initial state dysregulation may be attributed in part to infant general heightened reactivity. Indeed, maternal anxiety and depression during the third trimester have been found to predict as much as 27% of the variance in infant behavioral reactivity at four months (Davis et al., 2004).

Exposure to prenatal stress is also believed to negatively affect infants' capacities to engage in orienting and self-comforting behaviors. Infants exposed to prenatal stress appear to evidence lower durations of orienting, fewer orienting behaviors and less attentional control generally. Field and colleagues (2009) found that newborns of prenatally depressed mothers assessed at 12 days postpartum tended to orient to adult faces and voices as well as to their own pre-recorded cry sounds less often, suggesting an overall lack of attentiveness. Similarly, Lundy, Field and colleagues (1999) found that week-old newborns of prenatally depressed mothers tended to show lower durations of orienting, fewer interest behaviors and more pre-cry expressions. Finally, Huizink and colleagues (2002) found that infant exposure to maternal prenatal perceived stress and anxiety predicted observer ratings of infant inferior attentional control at three months and 8 months even after controlling for postnatal stress and depression. Although virtually no studies have examined the relation between prenatal stress and infant self-comforting behaviors, one study by Hernandez-Reif, Field and colleagues (2000) found that newborns of prenatally depressed mothers tended to spend 50% less time engaging in oral-object behaviors compared to newborns of non-depressed mothers, which they hypothesized could reflect infants' decreased capacity to engage in self-soothing behaviors. Infants exposed to stress prenatally may be less regulated because they are less able to employ effective regulatory behaviors in the face of distress.

Another mechanism through which prenatal stress might affect infant regulatory capacity is infant temperament. More specifically, to the extent that infant temperament necessarily affects infants' state regulation as well as their capacities to engage in regulatory behaviors, the observed relation between prenatal stress and infant regulatory

capacity may actually be attributed to the relation between prenatal stress and infant temperament. In a study that followed nearly 2000 mothers and their infants from late pregnancy to birth, Zuckerman and colleagues (1990) found that infants whose mothers reported higher levels of depressive symptomatology during pregnancy tended to cry more during a post-delivery physical examination and also to be less responsive to pediatricians' attempts to soothe the infant. Similarly, Huizink and colleagues (2002) found that mother reports of moderately high levels of perceived stress during pregnancy predicted infant "difficult" temperament type (i.e., infants characterized by negative mood, withdrawal, high intensity behaviors, irregular infant states) in their three-month-old infants. Furthermore, the effects of maternal prenatal stress, anxiety, and depression have been found to predict infant negative emotionality through age 5 (Martin, et al., 1999), even after controlling for maternal postnatal mood (Huot, Brennan, Stowe, Plotsky, & Walker, 2004; McGrath, Records, & Rice, 2008). However, whereas disparate studies have linked prenatal stress to infant temperament (Zuckerman, et al., 1990) and infant temperament to emerging regulation (Gartstein, et al., 2009), few or no studies to date have examined the extent to which the relation between prenatal stress and emerging regulation is mediated by infant temperament.

The Development of Self-Regulation in a High-Risk Context

Although regulatory processes emerging in the early childhood period are now widely recognized as important predictors of children's socioemotional adjustment, relatively few studies have extended findings about the development of self-regulation to populations with greater risk for adjustment problems. Specifically, although Mexican Americans are more likely to engage in risky behaviors; to experience less academic

achievement, more emotional problems, and more health problems; and to be involved more often in the criminal justice system (Cauce, et al., 2011), less is known about processes influencing socioemotional development in Mexican American children than for other ethnic minority groups (Carlo & de Guzman, 2009).

Moreover, although Mexican American mothers are believed to suffer from a health disparity, with disproportionately higher rates of prenatal distress compared to their Caucasian counterparts (Gress-Smith, et al., 2012), the influences of prenatal stress on infant regulatory systems in Mexican Americans are unclear. In fact, some studies examining the links between prenatal stress and infant birth outcomes in Mexican Americans have even found that Hispanic infants exposed to prenatal stress actually experience superior birth outcomes compared to their Caucasian counterparts (Jahromi, Umaña-Taylor, Updegraff, & Lara, 2012). Many of these studies speculate about the possible presence of an “Epidemiological paradox”, with cultural ties buffering against the negative influences of prenatal stress on infant birth outcomes. However, one of the few studies that has extended examinations of the influences of maternal distress to infant regulation suggests that the deleterious effects of fetal exposure to maternal distress may still be present (Field et al., 2002). Comparing pre- and post-partum influences of maternal prenatal depression on newborn physiological and behavioral regulation in Hispanic and Black mothers, Field and colleagues found that although Hispanic infants evidenced more signs of physiological (i.e., higher dopamine and lower cortisol levels) and behavioral (i.e., more regulated sleep patterns) regulation postpartum, they showed more signs of risk for poor regulatory development in-utero (i.e., more fetal activity) than

their Black counterparts. However, whether or not these infant regulatory risks observed prenatally may resurface across the early postpartum period is still largely unknown.

Current Study

The current study explored the pathways linking maternal prenatal stress to infant regulatory capacity by examining hypothesized contributions of infant temperament and maternal sensitivity in a high-risk, Mexican American sample. Three hypotheses were addressed: First, higher levels of infant engagement in each of the putative regulatory behaviors, self-comforting and orienting behaviors, will be negatively associated with changes in distress across the same period of time (*hypothesis 1*). Second, prenatal stress will predict infant regulatory behaviors such that higher levels of prenatal stress will be negatively related to infants' regulatory behaviors, but the relation will be fully mediated by infant temperamental characteristics (*hypothesis 2*). Specifically, higher levels of prenatal stress will predict higher levels of negative emotionality and surgency, and both will subsequently predict fewer regulatory behaviors. Finally, maternal sensitivity and infant temperament will not be concurrently related, but will interact to predict infant regulatory behaviors (*hypothesis 3*). Higher levels of infant negativity and surgency will predict less engagement in regulatory behaviors at low levels of maternal sensitivity, but will not be related to engagement in regulatory behaviors at high levels of maternal sensitivity. Findings extend current knowledge about the complex, transactional relations between prenatal stress, infant temperament, maternal sensitivity, and emerging regulation in a largely understudied, but increasingly prevalent, minority sample. A conceptual model is presented in Figure 1.

METHODS

Participants

The current study included data collected from a subset of the sample from a larger prospective longitudinal study, Las Madres Nuevas (LMN), investigating the course of postpartum depression and mother-infant coregulatory functioning in Mexican Americans. Participants were 305 mother-infant dyads from low-income, Mexican American families recruited during pregnancy through the Maricopa Integrated Health System (MIHS), the leading health care provider for low-income families in Maricopa County, Arizona. Eligibility criteria included fluency in either Spanish or English, self-identification as Mexican-American, anticipated delivery of a singleton (based on ultrasound results), and gestation prior to 34 weeks at the time of recruitment. Low-income status was determined by eligibility for Medicaid or by self-reported annual income below \$25,000. To date, LMN has achieved a 97% retention rate.

At the time of enrollment, mothers were on average 28 years old (range 18 – 42), had completed 10 years of education (mean= 9.93, sd= 3.52), were unemployed (76.6%), were unmarried and living with a romantic partner (50%), and had an annual household income of \$10,001 - \$15,000 a year (31%) to support four people (mean=4.26 people, sd=2.03). Most mothers were born in Mexico (81%) and spoke Spanish as their primary language (84%), but had been living in the U.S. for 12 years (range 0 – 32).

Procedures

Participation in LMN involved one prenatal home visit (34-37 weeks gestation), four home visits within the first six postpartum months (6, 12, 18 and 24 weeks), and one laboratory visit at 12 months. Data collection time points were corrected for infant

gestational age when infants were born at less than 37 weeks gestation. Because LMN employs a planned missingness design (Graham, Taylor, Olchowski, & Cumsille, 2006), all participants were expected to complete the prenatal, 6-week, and 12-month interviews, but each participant was randomly assigned to miss one of three 12-, 18- and 24-week data collection points. Planned missingness designs afford the opportunity to collect data from *more* participant families while only minimally affecting power (Graham, et al., 2006). Data for the current study drew from data obtained at three time points spanning from pregnancy to infant age 12 weeks: prenatal, 6, and 12 weeks, and corrected for planned missingness using Full Information Maximum Likelihood (FIML; (Allison, 2003).

Home Interviews. Eligible women were invited by a female, bilingual interviewer who obtained informed consent and detailed contact information and scheduled the first home visit during a prenatal care visit at MIHS. Home visits were conducted by bilingual female interviewers hired from the community and are administered in participant language of choice. Questions from the computer-assisted interview were read aloud to reduce error variance due to participant literacy. The structured interviews contain self-report measures as well as structured mental-health assessments.

Interaction tasks. Observational data were obtained from structured mother-infant interactions during the 6- and 12-week home visits and were recorded with two high-definition cameras for later coding. The current study focused specifically on data obtained during the peek-a-boo interaction task. For the peek-a-boo task, mothers were given a shield (e.g., book, blanket) and were instructed to play peek-a-boo with their

infants; mothers were provided with a demonstration only if they indicated that they did not know how to play. This task was chosen as a context because it was a stimulating activity that required both infant regulation and maternal sensitivity to infant cues.

Coding of data. Infant behaviors were coded using an adaptation of Tronick's Monadic Phases (E. Tronick, Als, & Brazelton, 1980) by four teams of two independent observers trained and supervised by a graduate research assistant. The microanalytic scoring system includes the coding of seven dimensions of infant behavior, four of which were considered for the current study. Inter-observer reliability was calculated for 20% of coded episodes by examining second-by-second agreement and calculating percent agreement and kappa reliability statistics following the stringent procedure established by Cohn and Tronick (1987). Because the videos were essentially selected at random (i.e., based on the availability of videos and the study planned missingness design), missing data were considered to be Missing At Random (MAR; Rubin, 1976) and thus corrected for using FIML in *Mplus* 6.12 (Enders & Bandalos, 2001). Mother behaviors were coded using a subscale of the Parent-Child Interaction Rating Scales (PCIRS; Belsky, Crnic, & Gable, 1995) by two independent coders supervised by a graduate research assistant. Coders were trained to 100% consensus and reliability was calculated for 20% of episodes.

Measures

Prenatal Stress. Mothers' self-report of family stressors were obtained during the prenatal home visit between 34-37 weeks gestation. Each of the ten family stressors that comprised the cultural/family conflict subscale of the Hispanic Stress Inventory was presented to each of the mothers, and a count for the number of family stressors she

reported experiencing in the past three months was computed (HSI; Cervantes, Padilla, & Salgado de Snyder, 1990). Stressors that were most frequently endorsed included: “Some members of your family have become too focused on themselves and less concerned about the family” (14%), “you have been separated from family because of money or immigration problems” (12%), and “your personal goals have been in conflict with family goals” (11%). The HSI family stress subscale has demonstrated sensitivity for capturing chronic stressors particularly poignant to Mexican-American women not otherwise captured by stress scales developed primarily for use with Caucasian samples (Goodkind, Gonzales, Malcoe, & Espinosa, 2008), and its predictive and concurrent validity has been established in a number of Hispanic samples (Cervantes, Padilla, & Salgado de Snyder, 1991; Rodriguez, Mira, Paez, & Myers, 2007; Salgado de Snyder, Cervantes, & Padilla, 1990). Alpha scale reliability for this scale in the current sample was .63.

Infants’ Regulatory Behaviors. Microcoded ratings of infant engagement in self-comforting or orienting regulatory behaviors were obtained at the 12-week home visits. Self-comforting was defined as infant engagement in one more of the following behaviors at any given time during the interaction: mouthing of self, object or mother, touching self, self-clasping, or rocking behaviors. Because the Peek-a-boo observational episode involved a highly stimulating caregiver and a highly stimulating object, and because infants who are overstimulated may focus attention elsewhere to reduce arousal, infant orienting regulation was defined as infant “looks away” behaviors (i.e., infant focuses on some object not immediately involved in the present interaction). Duration scores for each of the regulatory behaviors were obtained using the Observer XT 9.0

program to capture the amount of time infants engaged in self-comforting and orienting regulatory behaviors, and scores reflecting the proportion of time infants were engaged in each of the regulatory behaviors were calculated by dividing duration scores by total coded task time. Portions of tasks were sometimes unscorable due to limitations with camera positioning (e.g., infant face moved out of screen). Average percent agreement for self-comforting was 98%; Kappa reliability statistics could not be computed for self-comforting behaviors because the self-comforting codes were programmed as start-stop codes that were not mutually exclusive. Average percent agreement for infant gaze codes was 94% (kappa=.69).

Infant Distress. Microcoded ratings of infant distress were obtained at the 12-week home visits to verify the regulatory function of the aforementioned regulatory behaviors. Infant distress was defined as infant's displays of negative emotional expressions including sadness, fear/worry, frustration/anger, or grimace/disgust. Interobserver reliability for the scale was 96% agreement (kappa= .57). The three minute Peek-a-boo interaction was subdivided into two 90-second intervals, and proportion scores for the amount of time infants were observed displaying negative emotional expressions were calculated for each of the intervals. Change scores representing the overall increase, decrease, or constant state of distress for the interaction were calculated by subtracting the proportion of distress observed during the first half of Peek-a-boo from the proportion of infant distress observed during the second half of the task. Change scores ranged from -.28 to .45. The criterion established a priori for corroborating regulatory function was that infant regulatory behaviors should be negatively associated distress change scores across the interaction.

Infant Temperament. Maternal ratings of infant temperament were obtained at infant age 6 weeks via the Infant Behavior Questionnaire-Revised (IBQ-R, Gartstein & Rothbart, 2003). The IBQ-R is a 91-item questionnaire that asks mothers to rate how often they have observed concrete infant behaviors in the past 2 weeks. The IBQ-R is designed to assess temperament in infants up to 12 months, and evaluates nine temperamental constructs comprising two of three broad dimensions of infant temperament: surgency and negativity. Three of the total original forty items comprising the surgency dimension were omitted due to programming errors (items 28-30), but all other items were included and the dimensions kept intact. Scores for each of the dimensions were formed by averaging item scores for each of the subscales, and then by averaging subscale scores within each dimensions following practices by Gartstein & Rothbart (2003). Alpha scale reliabilities for the surgency and negativity dimensions for the current sample were .88 and .61, respectively.

Maternal Sensitivity. Observer ratings of maternal sensitivity were obtained at the 6-week time point during the peek-a-boo task using the sensitivity scale of the Parent-Child Interaction Rating Scales (PCIRS; Belsky, et al., 1995). Markers of mothers' sensitivity included: "acknowledging child's affect; contingent vocalizations by the parent; facilitating the manipulation of an object or child movement; appropriate soothing and attention focusing; evidence of good timing paced to child's interest and arousal level; picking up on the child's interest in toys or games; shared positive affect; encouragement of the child's efforts; providing an appropriate level of stimulation when needed; sitting on floor or low seat, at child's level, to interact." Maternal sensitivity was rated on a 5-point scale (1= almost no signs of parent sensitivity, 5= parent displays consistent

sensitivity throughout). 100% of ratings fell within +/- 1 point; and 50% of videos were coded to exact agreement. Because mother-infant interactions did not occur when infants were sleeping, data were coded as missing if infants were asleep for more than two minutes of the three minute task ($n=44$). These data were considered to be Missing At Random and were addressed using FIML for study analyses.

Potential Covariates. Demographic information and mother and infant health variables were considered as possible covariates in the present study. Demographic and mother health information (medical condition, use of prescription drugs) was obtained prenatally either during recruitment or at the home interview. Infant birth outcomes (gestational age, birth weight, 5-minute APGAR, days in hospital, and gender) were obtained from hospital birth records. Variables were entered as covariates if they were significantly correlated with both the outcome variables *and* their predictors, as specified in the model.

Data Analytic Plan

Hypothesis Testing. Hypothesis 1 was tested using Pearson correlations in SPSS 19. All remaining hypotheses were tested with a path analysis model using structural equation modeling (SEM) in *Mplus* 6 (Muthén & Muthén, 2010). Following Cohen, Cohen, West and Aiken (2003), all continuous predictors were centered and all categorical variables were dummy coded to reduce nonessential multicollinearity. Model fit was tested using χ^2 test of fit, root mean square error of approximation (RMSEA), standardized root mean square residual (SRMR), and the comparative fit index (CFI). Good fit was defined as χ^2 test probability value $>.05$, RMSEA values $\leq .06$, SRMR values $\leq .08$, and CFI values $\geq .95$ (Hu & Bentler, 1999). Tests of the mediated effects

proposed in hypotheses two through four were analyzed using bootstrapping (Shrout & Bolger, 2002). The interaction effects between maternal sensitivity and infant temperament dimensions were probed in simple slope analyses by using the model constraint command in *Mplus* 6.12 (Preacher, Curran, & Bauer, 2006).

Missing Data Handling. Because data collection for LMN is ongoing, data were not available for all participants at all timepoints, and observational data were available only for a subsample. Data available for each of the study variables were as follows: mother reports of family stress and demographic information during pregnancy, $n=304$; mother reports of infant temperament at 6 weeks, $n=266$; observations of maternal sensitivity at 6 weeks, $n=142$; observations of infant self-comforting behaviors at 12 weeks, $n=61$; observations of infant gaze behaviors at 12 weeks, $n=62$; observations of infant distress at 12 weeks, $n=84$. Because missingness was believed to be attributed to: the status of data collection (i.e., not all participants had completed all timepoints), random assignment of video observations to be coded, or, in the case of coded observations for maternal sensitivity, infants' wakefulness during the interaction task, missingness was determined to be missing at random (MAR; Rubin, 1976). Because recommendations in missing data handling research indicate that inclusion of all possible data points and subsequent corrections for missing data using techniques such as full information maximum likelihood (FIML; Enders & Bandalos, 2001) are optimal when data are missing at random (Schafer & Graham, 2002), full model analyses run in *Mplus* 6.12 FIML and included all available data points.

RESULTS

Preliminary analyses

Descriptive statistics for demographics, infant and mother health characteristics, and key study variables are presented in Table 1. Relations between demographics, health-related variables, infant temperament, maternal sensitivity, and infant regulatory behaviors were tested using Pearson correlations (see Table 2). Mothers who were born outside of the US, preferred Spanish, were married or living with a partner, and were less educated tended to report lower levels of family stress during pregnancy. Infants tended to be rated lower on temperamental surgency when mothers were born outside of the US, and when family incomes supported more people. Infants tended to be rated higher on temperamental negativity by mothers who had been living in the US for longer, who preferred to speak English, and who were not receiving prescription drugs. Maternal sensitivity, infant self-comforting behaviors, infant orienting behaviors, and changes in distress during the 12-week peek-a-boo task were unrelated to any demographic or health-related variables. Of note, mother's country of origin (0= US, 1=Mexico or Other), preferred language (0=English, 1=Spanish), and prescribed drugs (0=no, 1=yes) were related to both prenatal stress and infant temperamental characteristics; however, because mother's country of origin became non-significant when entered simultaneously into the model with mother's preferred language ($\beta = -.014, p=.961$), mother's country of origin was dropped as a covariate from analyses.

Regulatory Function of Infants' Regulatory Behaviors

Associations between infants' regulatory behaviors, self-comforting and orienting behaviors during the 12-week Peek-a-boo task and changes in infants' in observed

distress across the same task were tested using Pearson correlations. More engagement in self-comforting and orienting behaviors was negatively associated with changes in infant displays of distress across the Peek-a-boo task, though none of these associations was statistically significant at the $\alpha = .05$ level. Figure 1 displays mean rates of engagement in each of the regulatory behaviors by infants who experienced increases, constant, or decreasing levels of distress across the Peek-a-boo task. Post-hoc power analyses using G*Power 3.12 indicate that achieved power for the tested correlations between each of the regulatory behaviors and changes in distress given their sample sizes (self-comforting, $n=53$; orienting, $n=56$), was .11 and .35, respectively.

Direct and Indirect Relations between Prenatal Stress and Infant Regulation

The full SEM model examined the direct paths between prenatal stress and infant regulatory behaviors at 12 weeks, as well as the indirect pathways flowing through infant temperament and maternal sensitivity at 6 weeks (see Figure 2). Covariances between each of the mediating variables, as well as between both of the regulatory behaviors, were also estimated in the full model, but only covariances significant at the $\alpha = .05$ level are shown. Goodness of fit tests indicated that the full model fit the data well: $\chi^2(17) = 19.842$, $p = .28$; RMSEA=.02; CFI = .96; SRMR = .04.

Prenatal stress was significantly and positively related to infant orienting behaviors at infant 12 weeks of age, but not to infant self-comforting behaviors. Prenatal stress also showed significant, positive prediction to both infant temperamental negativity and surgency at infant 6 weeks of age. Infant surgency was not significantly associated with infant self-comforting or orienting behaviors. Infant negativity showed a marginally

significant, negative relation with self-comforting, but not orienting behaviors. Although maternal sensitivity was not directly related to either infant self-comforting or orienting behaviors, a significant interaction between maternal sensitivity and infant surgency emerged in the prediction of later orienting behaviors. Because significant paths were found that linked prenatal stress, infant negativity at 6 weeks, and infant engagement in self-comforting behaviors at 12 weeks, additional mediation analyses were conducted using bootstrapping with 2000 iterations in *Mplus* 6.12 (Shrout & Bolger, 2002). Results from the bootstrapping analyses indicated that the indirect effect was not significant at the $\alpha = .05$ level (95% CI [-.030, .005]).

Interaction between Maternal Sensitivity and Infant Surgency

The interaction between maternal sensitivity and surgency in the prediction of infant orienting behaviors was further probed with simple slope analyses in *Mplus* 6.12 using the model constraint command. Simple slopes of the relations between surgency and orienting were estimated at the mean, as well as at one standard deviation above and below the mean of maternal sensitivity, following steps described in Aiken and West (Aiken & West, 1991). A plot of the simple slopes for the interaction between maternal sensitivity and infant surgency is displayed in Figure 4. Infant surgency was a significant and negative predictor of orienting behaviors at low levels of maternal sensitivity ($\beta = -.121, p = .015$), but not at high levels ($\beta = .078, p = .102$) or mean levels of maternal sensitivity ($\beta = -.022, p = .472$).

DISCUSSION

The current study investigated infant and mother characteristics contributing to the development of self-regulation across the first twelve weeks of life in a low-income, Mexican American sample. Specifically, the study examined the regulatory functions of two putative regulatory behaviors—self-comforting and orienting behaviors—believed to play important roles in the development of self-regulation, as well as direct and indirect processes influencing their development beginning as early as pregnancy. Study findings were supportive of the notion that infants are capable of initiating behaviors to modulate distress as early as twelve weeks postpartum, and also suggest that exposure to maternal prenatal stress may set off cascades of influence on infant regulatory capacity even before infants are born, both by affecting tendencies for employing different regulatory behaviors, as well as by programming infant dispositional characteristics conferring risk for later regulatory difficulties.

Regulatory Functions of Infants' Regulatory Behaviors

The first study hypothesis was that self-comforting and orienting behaviors would serve regulatory functions, such that more engagement in those behaviors would be negatively related to changes in distress across the same interaction task. Although the associations between each of the putative regulatory behaviors and changes in distress across the same task were not statistically significant, they trended in the expected negative directions and achieved small and moderately small effects by Cohen's norms. Specifically, the more time infants engaged in either self-comforting or orienting behaviors across the entire Peek-a-boo interaction task, the more likely they were to experience decreasing levels of distress across the task. These trends are consistent with

findings from extant literature. For example, Crockenberg & Leerkes (2004) found that 6-month-old infants' orienting and self-comforting behaviors were observed more often during periods of decreasing distress. Similarly, in a study that investigated relations between gaze aversion and physiological measures of regulation (i.e., heart rate) during over-, under-, and appropriately stimulating interactions involving 4-month-old infants and their mothers, Field (1981) found that infants' heart rate was significantly more likely to accelerate in the five seconds before they averted gaze, but that it was significantly more likely to decelerate in the five seconds after they averted gaze. Put in other words, infants tended to look away from their mothers when they became more aroused, and looking away in turn was effective in helping to reduce arousal. Findings from the current study further corroborate the notion that infants may engage in behaviors that help to modulate distress as early as three months of age.

Maternal Prenatal Stress and Infant Regulatory Behaviors

The second study hypothesis was that prenatal stress would predict less engagement in self-comforting and orienting regulatory behaviors, but that their relations would be fully mediated by infants' temperamental negativity and surgency. That is, study hypotheses expected to find evidence for programming effects of prenatal stress on infant negativity and surgency, both of which in turn would in turn account for decreased regulatory efficacy observed in infants prenatally exposed to stress. And indeed, partial support for this hypothesis emerged. Prenatal stress was linked with infants' engagement in both self-comforting and orienting behaviors, but the paths linking prenatal stress and each of the regulatory behaviors varied in nature and in direction, suggesting that relations between prenatal stress and infant regulation are complex.

With respect to self-comforting behaviors, paths linking prenatal stress, infant temperamental negativity, and subsequent engagement in self-comforting behaviors emerged in the hypothesized directions, such that infant exposure to prenatal stress predicted more infant negativity, and infant negativity in turn predicted less engagement in self-comforting behaviors. This finding was consistent with other studies that have drawn links between prenatal stress and infant negativity (Davis et al., 2007); and infant negativity and impaired regulatory capacity (Calkins, et al., 2002). Moreover, that these relations emerged when they were considered *in the same study* provides compelling initial evidence to suggest that prenatal programming of infant negativity may be one mechanism through which prenatal stress may compromise infant regulatory functions.

Of note, rigorous bootstrapping tests of the total indirect effect indicated that we could not be confident that a true mediated effect was actually present. One possible explanation for the presence of intermediary pathways but the absence of a mediated effect may be that the observed relations between prenatal stress, infant negativity, and infant regulatory behaviors are better explained by their ties to some third variable not considered here. Specifically, prenatal programming is believed to be the result of fetal exposure to elevated levels of maternal cortisol in-utero, which consequently interferes with the normal development of infants' stress response system (i.e., the HPA-axis). Related, cortisol levels in infants prenatally exposed to stress have been found to mimic the elevated levels found in their mothers (Field et al., 2004), and have even been associated with higher incidence of infant negativity. For example, Baibazarova and colleagues (2012) found associations between prenatal stress, amniotic cortisol, and subsequent infant negativity in a study that followed nearly 160 women and their infants

from pregnancy through infant three months of age. Cortisol is also believed to be an index of HPA-axis functioning, with higher levels reflecting more dysregulated HPA-axis functioning that may consequently interfere with infants' capacities to engage in self-comforting regulatory behaviors (Fortunato, Dribin, Granger, & Buss, 2008). Future studies extending this literature should consider simultaneous influences of cortisol reactivity on infants' negativity as well as infants' capacities to engage in regulatory behaviors, and the extent to which cortisol reactivity may explain the observed links between negativity and self-comforting regulatory behaviors.

With respect to paths explaining relations between prenatal stress and orienting regulatory behaviors, the complex findings suggest that prenatal stress may actually exert multiple paths of influence on orienting. Specifically, direct and indirect effects of prenatal stress emerged in the prediction of orienting, with infant exposure to more prenatal stress directly predicting *more* engagement in orienting at twelve weeks, but also predicting more temperamental surgency, which in turn interacted with maternal sensitivity to predict more *and* less engagement in orienting. The finding that prenatal stress predicted more engagement in orienting behaviors was surprising and contrasted with previous research suggesting that exposure to prenatal stress predicts lower durations of orienting and less attentional control in general (Anja C. Huizink, et al., 2002; Lundy, et al., 1999). One conceivable explanation for these anomalous findings might be that because our sample tended to report moderate amounts of family stress, infants may actually have benefitted from exposure to those moderate levels of stress. Specifically, although few or no studies have pointed to possible benefits of exposure to prenatal stress for infants' attentional control, some studies have found that exposure to moderate levels

of prenatal stress has predicted other related positive outcomes. For example, in a study that followed nearly one hundred mild to moderately stressed, low-risk mothers and infants from pregnancy through 24 months, DiPietro and colleagues (2006) found that exposure to maternal depression and anxiety predicted more advanced mental and motor development when children were 24 months old, even after controlling for postnatal depression and anxiety. The authors concluded that exposure to mild and moderate levels of distress might actually be advantageous in enhancing fetal maturation in low-risk samples. However, because this finding was the only anomalous one that emerged from this study and because higher levels of prenatal stress appeared to predict greater temperamental risk, this explanation likely does not fully capture the true nature of the relations between prenatal stress and orienting behaviors.

Alternatively, there may have been other protective postnatal environmental factors not captured in the current study that mediated the positive relations between prenatal stress and orienting behaviors. For example, studies puzzled by similarly unexpected findings where infants of high-risk, Mexican American mothers actually enjoyed *superior* birth outcomes compared to their low-risk, Caucasian counterparts have pointed to the presence of an “epidemiological paradox”, by which some factor associated with enculturation in Mexican culture is believed to protect infants against the multiple risk factors they experience (Jahromi, et al., 2012; Padilla, Hamilton, & Hummer, 2009). Future studies should explore other caregiving and/or cultural factors that may help to counteract the negative effects of prenatal stress and further promote infants’ engagement in orienting behaviors.

Indirect pathways of influence were also observed between prenatal stress, infant temperamental surgency, and subsequent orienting behaviors. Similarly to self-comforting, findings suggested that exposure to more prenatal stress also programmed more temperamental surgency, which in turn played a role in predicting infants' later engagement in orienting behaviors. Though the positive associations between prenatal stress and infant surgency were in the expected directions, the finding is important because examinations of prenatal influences on surgency are relatively sparse in literature. Though it may seem counterintuitive at first to think that exposure to prenatal stress would predict a temperamental characteristic encompassing positive mood, surgency in fact captures a quality of positive *reactivity*, which captures elements both of positive mood *and* activity level. Though few or no studies to date have examined relations between prenatal stress and infant surgency, some studies have found links between prenatal stress and fetal activity in-utero. In fact, fetuses of depressed mothers have been found to be nearly twice as active as those of non-depressed mothers (Dieter et al., 2001). In concert with the positive prediction between prenatal stress and higher levels of both infant negative *and* positive reactivity, these findings suggest that prenatal stress may program infant general reactivity that is reflected in both temperamental negativity and surgency.

In fact, some studies that have addressed the connection between surgency and physiological reactivity have found relations parallel to those that have emerged between negativity and physiological reactivity. For example, in a study that examined exhibited salivary cortisol reactivity of 3 to 5 year old children when they were made to lose competitive games, Donzella and colleagues (2000) found that whereas most children

tended not to exhibit signs of cortisol reactivity, those who did tended to be the ones teachers described as higher in surgency. Moreover, in another study that considered associations between 3 to 5 year old children's physiological reactivity and both temperamental negativity and surgency, Davis and colleagues (Davis, Donzella, Krueger, & Gunnar, 1999) found that highly negative *and* highly surgent children similarly evidenced more physiological reactivity (i.e., more salivary cortisol reactivity) in response to the first few days of school. In so considering, it seems feasible to think that negativity and surgency may share an underlying physiological reactivity component—a component that may be heightened in infants prenatally exposed to stress.

Interactions between Maternal Sensitivity and Infant Surgency

However, in contrast to direct relations that emerged between negativity and self-comforting behaviors, surgency was not directly related to orienting, but rather interacted with maternal sensitivity to predict varying levels of orienting. As predicted by our third hypothesis, which expected to see impaired regulatory functioning for highly surgent infants *only* under conditions of low maternal sensitivity, but no relations between surgency and regulatory functioning under conditions of high maternal sensitivity, highly surgent infants engaged in high levels of orienting behaviors at high levels of maternal sensitivity, and low levels of orienting behaviors at low levels of maternal sensitivity. But unexpectedly, lowly surgent infants engaged in the *fewest* orienting behaviors at high levels of maternal sensitivity, and the *most* orienting behaviors at low levels of maternal sensitivity. While it is certainly possible that these findings reflect true relations between orienting and maternal sensitivity for lowly surgent infants, they may also simply be functions of study measurement and design. The current study assessed infant

engagement in each of the regulatory behaviors in the context of a dyadic peek-a-boo interaction task that likely elicited distress more often when mothers engaged in more overstimulating or intrusive behaviors, and thus less sensitive to infants' needs for stimulation. In this case, measurement of infant higher engagement in orienting behaviors may actually be confounded with less sensitive mother behaviors. Thus, the moderately high levels of orienting away behaviors observed in high sensitivity-high surgency mother-infant dyads may have more accurately captured infants' regulatory agility, whereas the very high levels of orienting away behaviors observed in low sensitivity-low surgency dyads may actually have reflected infant general disengagement from their overly stimulating mothers. It may be important for future studies investigating infant orienting behaviors to consider the extent to which their meanings may be context-specific.

Study Limitations

Although there were multiple design and methodological strengths, this study was not without its limitations. As touched on previously, because infant regulatory behaviors were assessed in the context of a Peek-a-boo interaction task, accuracy in measuring infants' regulatory efficacy was contingent on infants' experience of distress during a task otherwise intended to be a pleasurable dyadic interaction. Moreover, because infant orienting was defined as infant looking away from mother or task-related objects, the current study could not easily distinguish between purposeful gaze aversions with regulatory intent and the absence of eye contact reflecting infants' general lack of interest or inability to focus gaze in social interactions with their mothers. Future studies should consider infants' engagement in regulatory behaviors in infant-only tasks designed to

elicit frustration, or contrasts between infants' purposeful gaze aversion and other looking away behaviors. Another limitation was that the current study did not control for maternal postnatal psychological stress, and thus could not rule out the possibility that observed effects were a function of maternal postnatal, rather than prenatal stress. However, other studies that have similarly examined relations between prenatal stress and infant temperament or regulatory behaviors have found that influences of prenatal stress hold even after controlling for maternal postnatal stress (Davis, et al., 2007; O'Connor, et al., 2002). Finally, because the current study did not include indices of mothers' temperament, personality, or genetic contribution, we could not rule out the possibility that the apparent programming effects of prenatal stress on infant temperament were not simply the results of genetic transmission of negativity and/or surgency. Indeed, studies on the heritability of temperament have suggested that anywhere from fifty to eighty percent of variation in parents' reports of children's temperament may be attributable to genes (Goldsmith, Gottesman, & Lemery, 1997). However, studies examining influences of prenatal stress on infant developmental outcomes have found evidence for prenatal programming even in unrelated mother-infant dyads. In a study that contrasted influences of prenatal distress on offspring birth outcomes and later mental health in a samples of women who were biologically related and unrelated through in-vitro fertilization, Rice and colleagues (2010) found that prenatal anxiety and depression predicted offspring gestational age and birth weight, and antisocial behaviors in childhood for both related and unrelated pairs. Along similar lines, some evidence exists to suggest that prenatal exposure to stressful natural disasters is related to child later mental health problems (A. C. Huizink et al., 2007; Yehuda et al., 2005).

Summary and Conclusions

In summary, the current study examined processes spanning the prenatal and early postpartum period that influence the development of self-regulation in a sample of low-income Mexican American infants and their mothers, and provides evidence that there may be lasting implications of maternal prenatal stress for infant developmental and mental health outcomes. Whereas interventions targeting mothers' experiences of psychological distress during the prenatal period are of obvious importance both for promoting mothers' mental health and their offspring's positive developmental outcomes, it may also be important to help support mothers through the postnatal period as they're faced with the challenges of parenting their temperamentally reactive infants. Moreover, the positive linkage between prenatal stress and both infant negativity and surgency warrants further exploration, especially to investigate the commonalities that may reflect prenatal programming of general reactivity. The extent to which such connections converge or diverge over time would be important to determine. Finally, future studies should continue to investigate possible interactions between facets of the prenatal and postnatal environment, especially to examine possible moderating effects of maternal parenting and cultural factors on the development of self-regulation.

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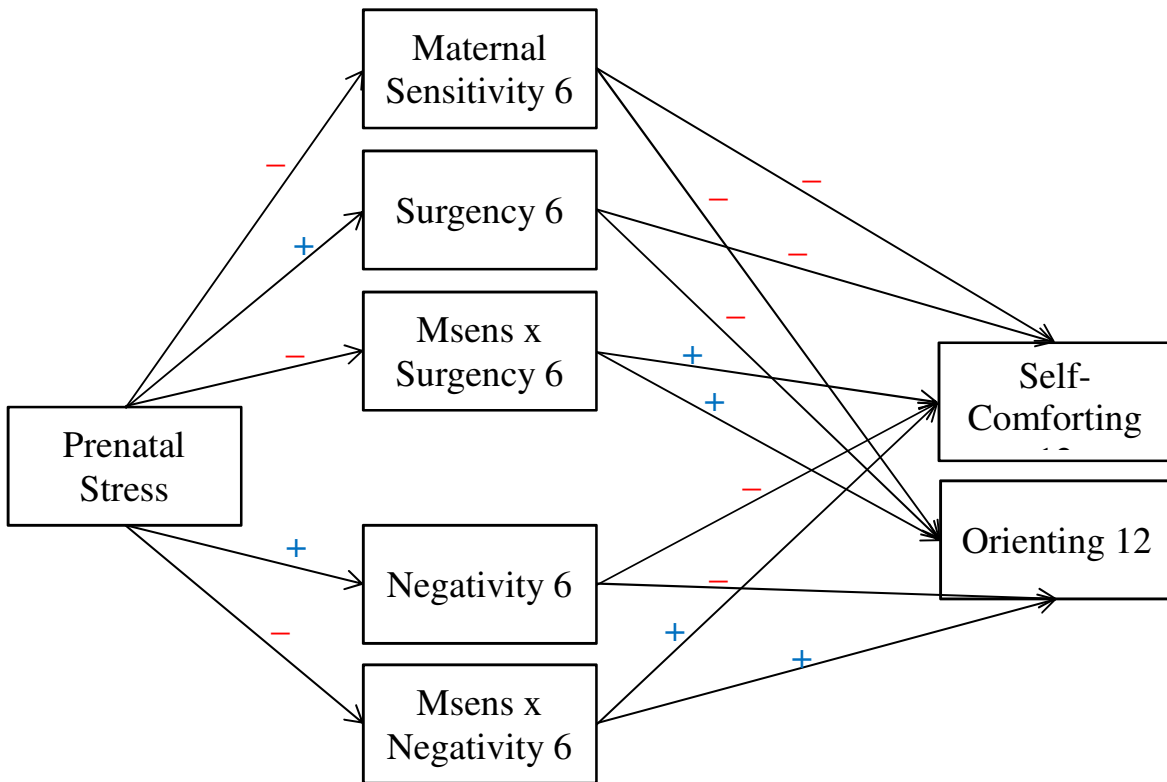


Figure 1. Conceptual Model

Table 1
Demographic and Descriptive Characteristics

<i>Infant</i>	Means (sds)
Gender (% male)	50.3%
Gestational Age	39.2 (1.5)
Birth Weight (grams)	3388.2 (469.1)
5 minute APGAR	8.9 (.5)
# Days in Hospital	2.5 (4.0)
<i>Family</i>	
Mother's mean age	27.45 (6.5)
Country of Origin	
% United States	14.1%
% Mexico	82.3%
% Other	3.6%
Preferred Language (% Spanish)	81.9%
Marital Status (% Married or Living Together)	78.4%
Mother's level of education (% high school degree)	39.0%
Median annual income	\$10,001 - 15,000
Mean # of people supported by income	4.3 (2.0)
% Diagnosed Medical Condition	21.6%
% Receiving Prescription Drugs	67.2%
<i>Key Study Variables</i>	
Mean # Family Stressors Endorsed	.8 (1.3)
Maternal Sensitivity (6 weeks)	2.4 (1.1)
Child Temperament: Negativity (6 weeks)	2.4 (.7)
Child Temperament: Surgency (6 weeks)	2.3 (1.1)
Proportion of task engaged in self-comforting (12 weeks)	.17 (.3)
Proportion of task orienting away (12 weeks)	.13 (.2)
Change in Distress across task (12 weeks)	.00 (.1)

Table 2

Correlations

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
<i>Demographics</i>																						
1. Mother's Age	-	.32	.16	.38	-.17	-.27	.07	.21	-.08	.06	.09	.02	-.10	-.03	-.09	-.08	-.11	-.09	-.12	.09	.11	.18
2. Country of Origin	-	-.05	.67	-.18	-.19	-.04	.07	.07	.01	.06	.08	-.17	.11	-.04	-.11	-.14	-.16	.01	.16	-.05	.04	
3. Years in US		-	-.09	-.18	-.02	.10	.02	.04	.02	.13	-.09	.13	.02	-.04	-.07	.04	.17	.13	-.26	.15	-.18	
4. Preferred Language			-	-.19	-.23	-.04	.19	-.01	.06	.04	.18	-.21	.08	-.04	-.16	-.12	-.14	.01	.16	-.04	-.07	
5. Marital Status				-	.02	-.17	-.07	-.13	-.04	-.05	.01	-.02	-.09	.10	.16	.11	.07	.01	-.03	.14	-.13	
6. Mother's Education					-	.25	-.17	.03	-.01	-.11	-.05	.05	.09	.03	.13	.11	.01	.07	.13	-.05	.04	
7. Family's Annual Income						-	.02	.07	-.03	-.07	-.08	.11	.09	.09	-.07	.00	.07	.10	.01	-.02	-.09	
8. # Supported by Income							-	-.03	-.03	.03	-.04	-.10	-.04	.02	-.08	-.14	-.08	.04	-.05	-.14	.12	
<i>Infant and Mother Health</i>																						
9. Infant Gender								-	.04	.02	-.04	-.03	-.02	-.06	-.03	.03	-.01	-.03	.03	.01	.11	
10. Gestational Age									-	.51	-.06	-.14	.06	.01	.01	-.12	-.08	.01	.09	.04	-.17	
11. Birth Weight										-	-.04	-.11	-.06	-.05	.06	-.09	-.05	.01	.25	.22	-.11	
12. 5 Minute APGAR											-	-.08	.05	.08	.05	.01	-.04	.06	.10	.08	-.03	
13. # Days in Hospital												-	.02	.07	.04	.04	.04	.04	.08	.01	-.04	
14. Mother Medical Condition													-	-.20	-.01	.00	-.10	.10	.04	-.37	-.11	
15. Mother Prescription Drugs														-	.14	-.01	.18	.00	-.10	-.06	-.05	
<i>Key Study Variables</i>																						
16. HSI family stress																-	.22	.21	-.02	-.11	.28	-.03
17. Temperamental Surgency																	-	.41	-.03	-.11	.06	-.04
18. Temperamental Negativity																		-	-.01	-.26	.06	-.15
19. Maternal Sensitivity																			-	-.06	-.02	.13
20. Self-Comforting Behaviors																				-	.06	-.10
21. Orienting Behaviors																					-	-.21
22. Change in Distress																						-

*Note. Listwise deletion was used; *n*'s ranged from 38 to 305. Variables were coded as follows: Country of origin, 0=US, 1=Other; Preferred Language, 0=English, 1=Spanish; Marital Status, 0=Married or Living together, 1=other.

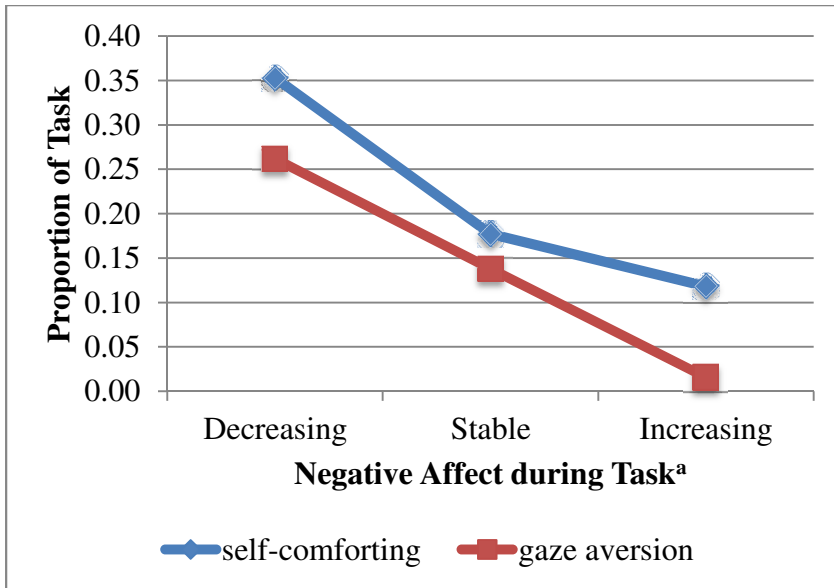


Figure 2. Infants' Engagement in Regulatory Strategies and Simultaneous Changes in Distress.

^aInfants with positive change scores greater than one standard deviation above the mean were considered to experience escalations in distress across the interaction task; infants with negative change scores less than one standard deviation below the mean were considered to experience reductions in distress; and infants with change scores within one standard deviation above or below the mean were said to maintain constant levels of distress throughout the interaction.

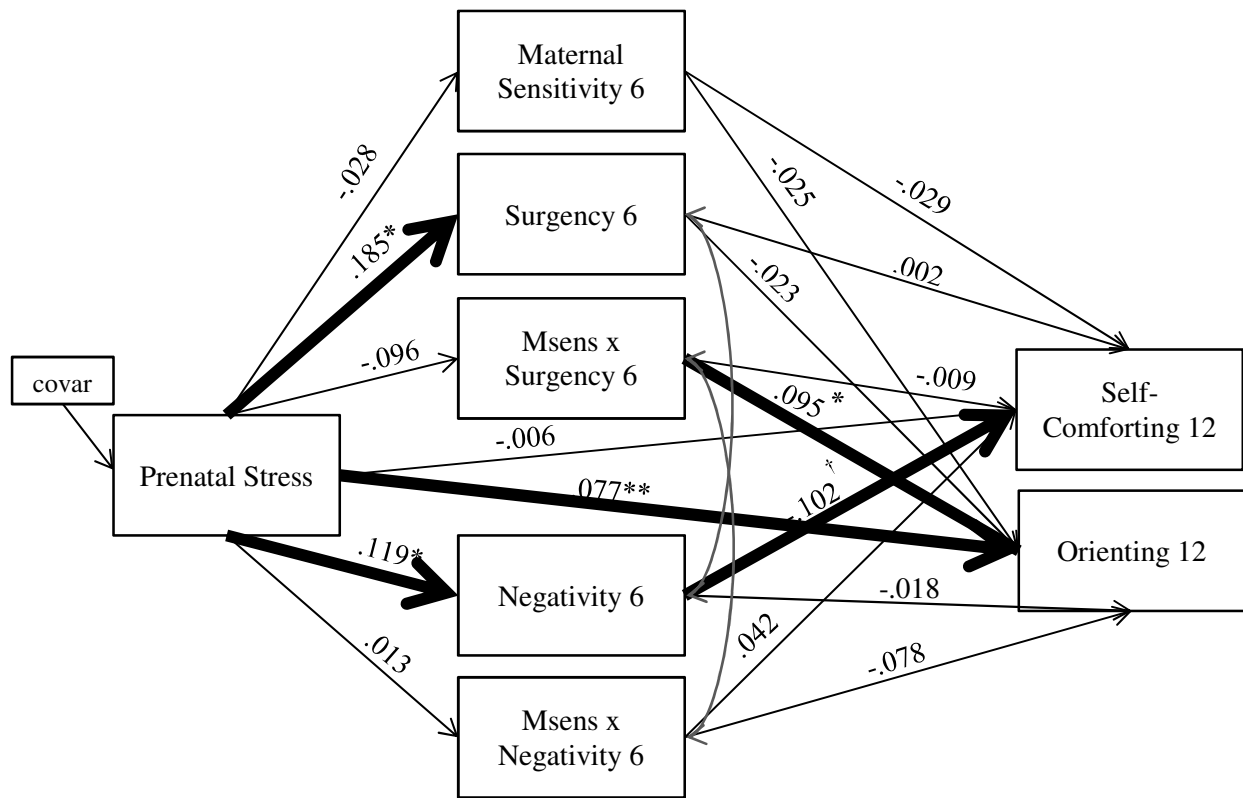


Figure 3. Model Results.

Covariates included mother's preferred language ($\beta=-.525, p=.006$), and prescription medications ($\beta=-.525, p=.006$). The full model estimated covariations between each of the mediating variables as well as between the regulatory strategies; only significant covariations are shown here. Alpha significance is notated as follows: $\dagger p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$.

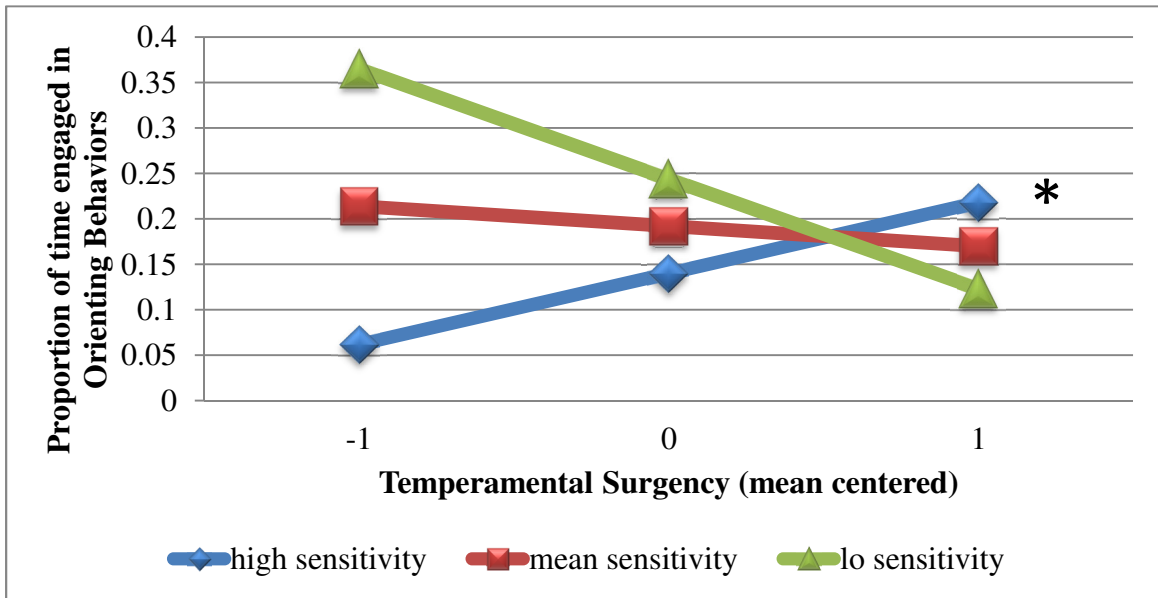


Figure 4. Relations between Maternal Sensitivity, Infant Surgency, and Orienting Behaviors.

*Alpha significance was at the $p < .05$ level.