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Infant Avoidance during a Tactile Task Predicts Autism Spectrum Behaviors in Toddlerhood

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Abstract

The experience of touch is critical for early communication and social interaction; infants who show aversion to touch may be at risk for atypical development and behavior problems. The current study aimed to clarify predictive associations between infant responses to tactile stimuli and toddler autism spectrum, internalizing, and externalizing behaviors. This study measured 9-month-old infants' (*N* = 561; 58% male) avoidance and negative affect during a novel tactile task in which parents painted infants' hands and feet and pressed them to paper to make a picture. Parent reports on the Pervasive Developmental Problems (PDP), Internalizing, and Externalizing scales of the Child Behavior Checklist were used to measure toddler behaviors at 18 months. Infant observed avoidance and negative affect were significantly correlated; however, avoidance predicted subsequent PDP scores only, independent of negative affect, which did not predict any toddler behaviors. Findings suggest that incorporating measures of responses to touch in the study of early social interaction may provide an important and discriminating construct for identifying children at greater risk for social impairments related to autism spectrum behaviors.

Keywords

touch; social development; autism spectrum behaviors

As the first sensory system to develop, touch is a primary modality through which infants and caregivers interact and communicate (Cascio, 2010; Ferber, Feldman, & Makhoul, 2008; Jean & Stack, 2009; Montagu, 1986; Moszkowski, Stack, & Chiarella, 2009). In non-human animals, social touch, such as grooming, has been found to support the formation of social bonds (Hertenstein, Verkamp, Kerestes, & Holmes, 2006). In humans, higher levels of touch between parent and infant (e.g., skin-to-skin contact, affectionate touch, tactile

game play) have been linked to secure attachment relationships, more positive social responses in infants, and positive reciprocal parent-infant interactions (Feldman, Eidelman, Sirota, & Weller, 2002; Ferber et al., 2008; Hertenstein et al., 2006; Stack & Muir, 1992). Based on the importance of touch for early development, it is possible that infants who show atypical responses to touch (e.g., over- or under-responsiveness) may be at risk for problems developing age-appropriate social and self-regulatory behaviors (Field, 2010).

Lack of or atypical touch between parents and offspring has been linked to abnormal social behaviors and repetitive, self-stimulatory behaviors in both human and non-human primates (Brandt, Baysinger, & Mitchell, 1972; Harlow & Harlow, 1962; Main & Stadtman, 1981); these *autism spectrum behaviors*[1] (i.e., abnormal social responses and repetitive behaviors) are related to Autism Spectrum Disorder (ASD) but are known to occur continuously in the general population (Edelson & Saudino, 2009; Spiker, Lotspeich, Dimiceli, Myers, & Risch, 2002; Whitehouse, Hickey, & Ronald, 2011). Ornitz (1983) suggested that abnormal responses to sensory input *underlie* behaviors related to ASD, and subsequent studies have shown that children's early atypical sensory responses, such as the avoidance of touch, are predictive of later ASD (Adrien, Ornitz, Barthelemy, Sauvage, & Lelord, 1987; Baranek, 1999; Ben-Sasson & Carter, 2013; Brisson, Warreyn, Serres, Foussier, & Adrien-Louis, 2012). Indeed, in light of the growing body of clinical studies suggesting the relation between sensory functioning and autism spectrum behaviors, the most recent edition of the *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition* (*DSM-V;* American Psychiatric Association, 2013) included abnormal sensory response in the diagnostic criteria for ASD. Although autism spectrum behaviors have been studied in both clinical and normative samples, to date, the relation between touch avoidance and later autism spectrum behaviors has been examined only in clinical samples.

Like internalizing and externalizing behaviors, autism spectrum behaviors occur on a continuous spectrum in the general population; moreover, autism spectrum behaviors show stability from childhood to adolescence (Robinson et al., 2011) and, specific to males, from early childhood to adulthood (Whitehouse et al., 2011). Nevertheless, compared to internalizing and externalizing behaviors, autism spectrum behaviors have been studied to a lesser extent in non-clinical samples. Studies using at-risk samples have found that infant siblings of children with ASD show social impairments, including limited eye contact, social smiling, and social gestures (Bryson et al., 2007; Georgiades et al., 2013; Zwaigenbaum et al., 2005). Recent research in this area has also used a dimensional approach to examine autism spectrum behaviors and their implications for social development in normative samples. For instance, one study using a large, normative sample of toddlers found that a higher level of autism spectrum behaviors, measured using the Child Behavior Checklist (CBCL) Pervasive Developmental Problems (PDP) scale (Achenbach & Rescorla, 2000), was related to less social engagement (Edelson & Saudino, 2009). Thus, even in the general population, higher levels of autism spectrum behaviors may be indicative of greater social impairment. The current study expanded on prior research that has found links between

[1]When studied in non-clinical samples, behaviors characteristic of ASD have been called, variously, autism behaviors, autistic traits, autistic-like behaviors, autism spectrum problems. We adopt the term, *autism spectrum behaviors*, which is most consistent with prior research and current conceptualizations of these behaviors as occurring dimensionally in the general population.

tactile avoidance and ASD by examining infants' avoidance behavior during an interactive task that provided substantial tactile stimulation as a possible predictor of autism spectrum behaviors in a normative sample.

Prior studies have found that heightened avoidance of touch during infancy predicts later ASD diagnosis (e.g., Baranek, 1999), which suggests that tactile avoidance may be related to the development of autism spectrum behaviors. For instance, tactile avoidance may be an early manifestation or correlate of autism spectrum behaviors. Another possibility is that tactile avoidance may lead to impairments in social relationships, which could lead to increases in autism spectrum behaviors, which could, in turn, further impair social relationships. Although it is not yet clear whether infant tactile avoidance plays a causal role in the development of autism spectrum behaviors or is simply a correlate of autism spectrum behaviors, recent research has focused on the influence of early infant behavior on social outcomes by shaping the environmental context for social development. Indeed, researchers have posited that infants' reactivity to physical and social stimuli (e.g., avoidance of touch) evokes specific social responses from others and influences the selection of social environments, thus shaping children's social trajectories over time (Meek, Lemery-Chalfant, Jahromi, & Valiente, 2013). For example, low levels of early social behaviors (e.g., joint attention) have been found to predict less engagement with caregivers and peers, as well as more exclusion by peers at school-age (Meek, Robinson, & Jahromi, 2012). With regard to touch avoidance, an infant with a tendency to avoid touch from caregivers may receive fewer social initiations and less positive responses from parents and may also self-select solitary activities that do not involve touch from others; such environments, in turn, may provide fewer opportunities to develop social skills and meaningful relationships during infancy and early childhood, perhaps leading to greater social impairments and less social motivation across time. In this way, the avoidance of touch may shape social trajectories by removing an important modality for sharing communication, intimacy, and emotion, setting in motion a cascade of negative effects on child social development. Although this model fits well with theories of social development, it is also possible that avoidance of touch is a related phenomenon that does not play a causal role in the development of ASD.

Because no work to date, of which we are aware, has examined relations between early tactile avoidance and later autism spectrum behaviors in a normative sample, the primary aim of the current study was to examine infants' responses to tactile stimulation in relation to toddler autism spectrum behaviors. Of importance, it is possible that an avoidant response to touch may be a manifestation of negative emotionality (e.g., heightened distress in response to blocked goals or novel stimuli), rather than an atypical sensory response leading to diminished social responsiveness and interaction. Indeed, tactile avoidance and negative affect frequently co-occur (Klein, Laish-Mishali, & Jaegermann, 2008), and quite possibly, infants' avoidant behavior (e.g., struggling, pulling, pushing, gazing away) during tactile stimulation could be part of a more general distress response, not simply an attempt to minimize tactile input. If this were the case, we might expect greater tactile avoidance to predict later problems regulating emotions (e.g., internalizing and externalizing behaviors) rather than only autism spectrum behaviors; in fact, abnormal sensory responses have been related to higher levels of internalizing, externalizing, as well as autism spectrum behaviors in prior research (Ben-Sasson & Carter, 2013; Bron, van Rijen, van Abeelen, & Lambregtse-

van, 2012). However, measures of tactile avoidance in prior research have typically subsumed negative affect as part of measures of avoidance (e.g., Baranek, 1999), making it difficult to determine whether tactile avoidance and negative affect predict distinct outcomes.

Therefore, a secondary aim of the current study was to clarify predictive associations between infant avoidance and negative affect during tactile stimulation and toddler autism spectrum, internalizing, and externalizing behaviors. We observed avoidance behaviors and negative affect in a parent-child interaction task that delivered novel tactile stimuli when infants were 9 months old, as predictors of parent reports of 18-month-olds' problem behaviors. Individual differences in behavioral responses to sensory stimulation can be reliably measured by 9 months of age (DeGangi & Greenspan, 1989; Fairhurst, Löken, & Grossmann, 2014), and early indicators of autism spectrum behaviors and regulatory problems have also been found at this age (Baranek, 1999; Lipscomb et al., 2012), though it should be noted that very few studies have identified predictors of autism spectrum behaviors at 9 months of age.

We used a structured task that required parents to deliver tactile stimulation by painting their infants' feet and hands and pressing them on paper to make a picture (The Flower Print Task) to measure infants' avoidance (i.e., looking away from the task and physically resisting the task) and negative affect (i.e., facial and vocal cues) specifically in response to tactile stimuli within a social context. Our measurement of avoidance during tactile stimulation was consistent with research that has revealed a pattern of behaviors that infants use to minimize or avoid sensory stimulation (DeGangi & Greenspan, 1989; Dunn & Daniels, 2002; Goldsmith, 1996). To measure toddler problem behaviors, we used scores on the PDP, Internalizing, and Externalizing scales of the CBCL (Achenbach & Rescorla, 2000).

The PDP scale is a valid measure of autism spectrum behaviors in normative samples that may indicate risk for problems developing social relationships. Indeed, young children with higher PDP scores show less social engagement in childhood and show more autism spectrum behaviors in early adulthood (Edelson & Saudino, 2009; Whitehouse et al., 2011). In addition, several studies have demonstrated concurrent validity and high sensitivity and specificity of the PDP scale for distinguishing between children with ASD and typically developing children (Halleröd et al., 2010; Kaat, Lecavalier, & Aman, 2014; Mirenda et al., 2010; Sikora, Hall, Hartley, Gerrard-Morris, & Cagle, 2008); this suggests that scores in the clinical range indicate risk for ASD, though it should be noted that most studies have examined the validity of the PDP scale in older children, as opposed to toddlers.

To meet the primary aim of the study, we examined the relative contributions of infant avoidance behaviors and negative affect during tactile stimulation in predicting toddler autism spectrum behaviors. Relatedly, we also examined whether avoidance behaviors would differentially predict autism spectrum behaviors and whether negative affect would differentially predict internalizing and externalizing behaviors. As no prior work has examined relations between tactile avoidance and autism spectrum behaviors measured dimensionally in a normative sample, we made no specific hypotheses.

Method

Participants

This study included participants (N = 561) from the ongoing Early Growth and Development Study (EGDS), a prospective, longitudinal study of adoptive families in the Pacific Northwest, West/Southwest, Mid-West, and Mid-Atlantic regions of the United States. Each adoption triad consisted of the adopted child, adoptive parents, and at least one birth parent. See Leve, Neiderhiser, Shaw, Ganiban, Natsuaki, and Reiss (2013) for detailed information on recruitment and assessment procedures and detailed sample information. The current study aimed to examine the relation between infant avoidance behaviors during tactile stimulation and toddler autism spectrum behaviors; although the design of the current study would also permit examining specific genetic and environmental factors that may moderate this relation, because of space limitations we were not able to investigate such associations in the current study.

The median child age at adoption placement was 2 days (SD = 12 days, range = 0 – 91), and 42 percent of the children were female. The current investigation included data collected from the adoptive parents and children when children were 9 (M = 9.29, SD = .59, range = 8.25 – 14.29) and 18 (M = 18.06, SD = .85, range = 15.64 – 25.23) months of age, and birth mother reports of prenatal experiences at 4 months postpartum. In general, adoptive parents were college–educated and middle class (Household Income: median = $124,917, SD = $101,729, range = $7,000.00 – $1,500,000.00). Mean ages of adoptive mothers and fathers (at infant age 9 months) were 38.17 (SD = 5.45, range = 25.57 – 55.82) and 39.22 years (SD = 5.90, range = 26.29 – 60.55), respectively. The sample of adoptive mothers was largely White (93.7%; African American = 2.2%, American Indian/Alaska Native = 0.2%, Asian American = 0.9%, more than 1 race = 0.9%), as was the sample of adoptive fathers (92.2%; African American = 3.9%, Asian American = 0.6%, Native Hawaiian/Pacific Islander = 0.6%, more than 1 race = 1.3%). Approximately 2.2 percent of adoptive mothers and 1.3 percent of adoptive fathers were Hispanic. On average, adoptive parents had been married for 11.10 years (SD = 5.08, range = .76 – 26.26). The majority of birth parents had completed high school or trade school and most reported household incomes below $25,000. The mean age of birth mothers (at 4 months postpartum) was 24.78 (SD = 5.94, range = 14.25 – 43.82), and although the sample of birth parents was more racially diverse than adoptive parents, the majority (72.6%) of birth mothers were White (African American = 11.4%, American Indian/Alaska Native = 3.1%, Asian American = 1.5%, more than 1 race = 4.8%, unknown/did not report = 0.2%), and approximately 6.3 percent of birth mothers were Hispanic.

Only families with complete data at both times of adoptive family assessments (9 and 18 months) were included in the current study. The Flower Print Task required the participation of both parents to complete the activity, and data were missing due to: only one parent being available to participate because of scheduling constraints (n = 17) or single-parent family (n = 10); data available at only one time point (n = 58); and technical problems with video/sound equipment (n = 14). This resulted in an analytic sample of 462 families (adoptive parents, adopted child, and birth mother). Participating families did not differ significantly

from nonparticipating families on indicators of: parent education, parent age, or adoptive parent ratings of toddler behaviors. Participating adoptive families had significantly lower household incomes than those excluded ($F(1, 511) = 4.97$, $p < .05$).

Procedure

Observational data from adoptive parents and their adopted infants (age 9 months), birth mother reports on prenatal environment (4 months postpartum), and adoptive parent reports of toddler behaviors (age 18 months) were included in the current study. A 2.5-hour birth mother assessment was completed in the home or some other convenient site at 4 months and 2.5–3.5 hour adoptive family assessments took place in the home at infant ages 9 and 18 months. Adoptive parents completed several tasks independently with the adopted child. The Flower Print Task included both parents and the infant and is the focus of the current study. All participants received monetary compensation for volunteering their time to participate in the study. Separate teams of trained interviewers completed birth and adoptive family assessments to preclude any sharing of data across birth and adoptive families. Detailed information on the EGDS procedures and assessments can be found in Leve et al. (2013).

Observed Avoidance and Negative Affect

The Flower Print Task was originally designed for the EGDS by the third author to assess how parents interact with each other in a co-parenting situation. The task required adoptive parents to paint their 9-month-old infants' hands and feet and then to press them to a piece of paper to create a flower design. The adoptive parents followed step-by-step instructions to make a flower painting using their babies' hands and feet. Paper, paintbrushes, several bottles of paint, a bib, and wet wipes were provided for parents, and parents worked together to complete the task. Typically, one parent held and moved the infant while the other parent painted and pressed each of the infant's hands and feet to the paper and then cleaned the baby. This task was ideal for assessing both infants' avoidance and negative affect in response to a novel tactile experience.

Infant behaviors and affect were micro-coded second-by-second, based on a coding system designed for the current study, which was informed by existing coding systems that have been used reliably to code infants' distress and behavioral responses to touch during parent-child interactions (Feldman, Keren, Gross-Rozval, & Tyano, 2004; Feldman, Weller, Sirota, & Eidelman, 2003). Behaviors and affect were coded only during the delivery of tactile stimulation, that is, when the infants' hands and feet were being painted, pressed to the paper, and cleaned off with wet wipes. Thus, infants' avoidance behaviors and negative affect were measured only during the provision of tactile stimulation. Three categories of infant behaviors were coded: direction of gaze (e.g., toward tactile stimulus, away from the task), physical resistance (e.g., struggling, pushing or pulling away from stimulus), and negative affect (facial and vocal cues). Categories were not mutually exclusive so that, for example, negative affect could be coded as occurring at the same time as resistance. A team of undergraduate research assistants was trained to code infants' behaviors and affect. Seventeen percent of the interactions were double-coded to establish reliability ($n = 87$). Coefficient kappas for each category ranging from .80 to .84 demonstrated high inter-rater reliability.

The percentages of time that infants looked away, showed physical resistance, and showed negative affect were computed. To create a measure of avoidance, the percentages of time infants showed physical resistance and gazing away during tactile stimulation were standardized and composited, which is consistent with prior measures of avoidant responses to sensory stimulation (DeGangi & Greenspan, 1989; Dunn & Daniels, 2002; Goldsmith, 1996); indeed, both physical resistance and gazing away have been used to measure avoidance within the context of sensory stimulation, and the two behaviors were assumed to have the same function of avoiding or reducing tactile stimulation during the Flower Print Task. Following prior research (e.g., Gagne, Van Hulle, Aksan, Essex, & Goldsmith, 2011), the percentage of negative affect was standardized and used as a measure of infants' negativity in response to a novel experience.

Parent-Reported Toddler Behaviors

Adoptive parents completed the CBCL (Achenbach & Rescorla, 2000) to rate their 18-month-old children's problem behaviors. The CBCL is composed of 99 items describing various problem behaviors that parents rate on a 3-point scale (0 corresponds to "not true", 1 corresponds to "sometimes true", and 2 corresponds to "very true"). Specifically, the 13-item Pervasive Developmental Problems (Adoptive Mother $\alpha = .57$; Adoptive Father $\alpha = .62$), 36-item Internalizing (Adoptive Mother $\alpha = .73$; Adoptive Father $\alpha = .77$), and 24-item Externalizing (Adoptive Mother $\alpha = .87$; Adoptive Father $\alpha = .88$) scales were used in the current study. The lower Cronbach's alpha coefficients for the PDP scale are consistent with prior studies that have used this scale in non-clinical samples (e.g., Edelson & Saudino, 2009; Whitehouse et al., 2011).

The Internalizing scale measures symptoms of emotional reactivity, anxiety, depression, withdrawal, and somatic problems. The Externalizing scale measures aggressive and inattentive behaviors and problems regulating anger and frustration. The PDP scale was constructed to measure autism spectrum behaviors, based on criteria from the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (*DSM-IV*; American Psychiatric Association, 1994; see Table 1). Raw scores were converted into T-scores for each scale; T-scores below 65 are considered in the Normal Range, those between 65 and 69 are in the Borderline Clinical Range, and those above 69 are in the Clinical Range. In this normative sample, parent ratings on the PDP scale for the majority of children were in the Normal Range (see Table 2); parent ratings for five children were in the Borderline Clinical Range, and parent ratings for one child were in the Clinical Range. The CBCL shows good reliability and validity (Achenbach & Rescorla, 2000), and prior research suggests that the CBCL PDP scale is a useful screening tool for identifying risk for ASD, showing high sensitivity and specificity for distinguishing between typically developing children and those with ASD (Muratori et al., 2011; Narzisi et al., 2013; Ooi, Rescorla, Ang, Woo, & Fung, 2011; Predescu et al., 2013; Sikora et al., 2008). Ratings from adoptive mothers and fathers, which were significantly correlated ($r = .42$, $p < .001$ for Internalizing scale; $r = .42$, $p < .001$ for Externalizing scale; $r = .32$, $p < .001$ for PDP scale), were composited for each scale; ratings from a single parent were used when ratings from only one parent were available.

Obstetric Complications

Prior research suggests that the EGDS sample evidenced somewhat elevated levels of pre- and perinatal risks (Marceau et al., 2013), which have been found to be associated with abnormal sensory responses (Crepeau-Hobson, 2009) and ASD symptoms (Gardener, Spiegelman, & Buka, 2009). Birth mothers reported on pre- and perinatal experiences across five categories: exposure to drugs and alcohol, exposure to toxins, maternal psychopathology during pregnancy, pregnancy complications, and neonatal complications. A perinatal risk index was created using a scoring procedure similar to the McNeil-Sjöström System, which has been used to quantify pre- and perinatal risk exposure (Marceau et al., 2013; McNeil, 1995; McNeil & Sjöström, 1995). A measure of overall obstetric complications was created by compositing scores across the five categories.

Results

Descriptive Statistics

Means, standard deviations, and ranges of study variables can be found in Table 2, and correlations among all study variables are summarized in Table 3. Consistent with prior research (Klein et al., 2008), infant avoidance behaviors and negative affect during the Flower Print Task were positively and significantly correlated ($r = .30$, $p < .001$). A significant, albeit modest, negative correlation between adoptive family household income and infant avoidance behaviors also emerged ($r = -.10$, $p < .05$), consistent with prior studies that have found that lower socioeconomic status is associated with greater difficulties responding to sensory stimuli (e.g., Ben-Sasson, Carter, & Briggs-Gowan, 2009). Additionally, there were significant positive correlations among the CBCL PDP, Internalizing, and Externalizing scales (see Table 3).

Although evidence for sex differences in sensory responses is mixed (e.g., Cheung, & Siu, 2009; Dunn & Westman, 1997; Goldsmith, Lemery-Chalfant, Schmidt, Arneson, & Schmidt, 2007), there were sex differences in levels of infant avoidance behaviors ($F(1, 460) = 6.88$, $p < .01$, $f^2 = .02$), such that male infants had higher avoidance scores during the Flower Print Task than female infants ($M = .08$, $SD = .87$ for males; $M = -.12$, $SD = .72$ for females).

Based on preliminary analyses that revealed significant correlations among the CBCL PDP, Internalizing, and Externalizing scales, when examining the relation between infant behavior and a toddler outcome in main analyses, the remaining two CBCL scales were included as covariates (i.e., Internalizing and Externalizing were controlled when examining PDP as an outcome). Although there were sex differences in avoidance behaviors, and household income was significantly correlated with avoidance behaviors, neither variable was related to toddler outcomes. Further, although prior research has found associations between prenatal experiences and abnormal sensory responses (Crepeau-Hobson, 2009), obstetric complications ($M = 9.61$, $SD = 6.70$, range = .00 – .39) and infant/toddler behaviors were uncorrelated. Because results reported below were similar with or without infant sex, household income, and obstetric complications in the models, we reported findings from the most parsimonious models that did not include these covariates.

Avoidance Behaviors Predicted Toddler Autism Spectrum Behaviors

Three separate hierarchical linear regressions were used to examine predictive associations between infant avoidance behaviors and negative affect during tactile stimulation in the Flower Print Task at 9 months and adoptive parent reports of children's PDP, Internalizing, and Externalizing scores at 18 months. For each of the three CBCL scales as dependent variable, a three-step model was used with covariates (i.e., remaining two CBCL scales) entered in Step 1, infant observed negative affect entered in Step 2, and infant observed avoidance entered in Step 3.

Table 4 summarizes the results of the hierarchical regression predicting PDP scores. Infant avoidance scores significantly predicted level of PDP scores 9 months later ($\beta = .11$, $p < .01$). The model accounted for statistically significant portions of the variance in PDP ($F(4, 457) = 81.75$, $p < .001$, $R^2 = 42$). The overall models predicting Internalizing ($F(4, 457) = 159.67$, $p < .001$, $R^2 = .58$) and Externalizing ($F(4, 457) = 70.46$, $p < .001$, $R^2 = .38$) scores were significant, due to the significant relations among CBCL scores (which were included as covariates). That is, PDP ($\beta = .49$, $p < .001$) and Externalizing ($\beta = .45$, $p < .001$) scores significantly predicted Internalizing scores, and PDP ($\beta = -.10$, $p < .05$) and Internalizing ($\beta = .67$, $p < .001$) scores significantly predicted Externalizing scores. Neither negative affect nor avoidance behaviors significantly predicted levels of Internalizing or Externalizing at 18 months of age.

Discussion

Touch is a primary modality through which infants and caregivers interact and communicate (Ferber, Feldman, & Makhoul, 2008; Jean & Stack, 2009; Montagu, 1986; Moszkowski, Stack, & Chiarella, 2009). Whereas higher levels of touch between parent and infant (e.g., skin-to-skin contact, affectionate touch, tactile game play) have been linked to more positive social responses and interactions during infancy (Feldman, Eidelman, Sirota, & Weller, 2002; Ferber et al., 2008; Hertenstein et al., 2006; Stack & Muir, 1992), lack of or atypical touch may disrupt infant social development (Main & Stadtman, 1981). For instance, infant tactile avoidance may evoke less positivity and social initiations from others and could influence children's self-selection of solitary, rather than social activities, thus, shaping their social development. Indeed, infant tactile avoidance has been found to predict later autism diagnosis (Baranek, 1999), although prior research has not examined the relation between touch avoidance and later autism spectrum behaviors in a normative sample. On the other hand, tactile avoidance could also simply be part of a more general distress response (e.g., negative affectivity), in which case we would expect tactile avoidance behaviors to predict later problems regulating emotions (e.g., internalizing and externalizing behaviors). Therefore, the current study aimed to clarify predictive associations between infant tactile avoidance and negative affect and later autism spectrum, internalizing, and externalizing behaviors in toddlerhood.

We examined two specific, observable infant behaviors-- avoidance and negative affect—during the delivery of tactile stimuli as predictors of toddler problem behaviors in a sample of adopted children. Consistent with prior research (Klein et al., 2008), infant avoidance and negative affect were significantly correlated. However, only avoidance significantly

predicted autism spectrum behaviors over and above the effects of negative affect on autism spectrum behaviors, and avoidance did not predict internalizing or externalizing behaviors during toddlerhood. This suggests that it is specifically the behavioral *avoidance* of a novel tactile experience, and not a distress response to this challenge, that predicts social and repetitive behaviors. While an infant may show negative affect during tactile stimulation, it may be that behavioral avoidance, specifically, has more severe consequences for social relationships. Tactile avoidance, independent of negative affect, could be a sensory withdrawal response to a presumably aversive experience, whereas negative affect, which may be an approach or withdrawal response, could serve as a social signal to the caregiver that the child is fearful, angry, or distressed. Overall, tactile avoidance appears to be a process that specifically predicts social and repetitive behaviors. Further research will be necessary to clarify the role (as cause, correlate, early manifestation) of tactile avoidance in the development of autism spectrum behaviors. One possible explanation of the current findings is that avoidance behaviors are seen as odd by others and do not convey a clear signal of the child's emotional state to others, thus interfering with the development of healthy social relationships.

Although one strength of this study was that tactile avoidance was examined in a social context, another interpretation of findings is that the relation between infant avoidance and later autism spectrum behaviors is explained by variation in the quality of parent-child relationships. For instance, infants' gaze aversion and physical resistance during the Flower Print Task could have been directed at parents and, thus, may have been indicative of the quality of the parent-child relationship, rather than avoidance of tactile stimuli. Moreover, many of the PDP items may reflect the parent-child relationship (e.g., "Seems unresponsive to affection"), and it is likely that parents reported on social behaviors observed during their own interactions with the child. It is also possible that infant avoidance behaviors during the Flower Print Task were indicative of social aversion, another type of infant behavior that has been found to predict later autism diagnosis (Ozonoff et al., 2010), rather than the avoidance of tactile stimuli, specifically. Although we cannot determine whether infant avoidance was in response to the social press of the Flower Print Task or to tactile stimulation, prior research has shown that both social and sensory aversion are predictive of later ASD diagnosis (Baranek, 1999; Ben-Sasson & Carter, 2013) and that sensory abnormalities that predict autism spectrum behaviors span both social and non-social sensory stimuli (Baranek, 1999). Further, because avoidance was measured only during the delivery of tactile stimulation in the Flower Print Task and was consistent with prior measures of sensory avoidance (DeGangi & Greenspan, 1989; Dunn & Daniels, 2002; Goldsmith, 1996), it is likely that avoidance behaviors measured an aversive tactile, rather than social response. However, future research should make use of both social and non-social paradigms for examining children's responses to touch, which may help to disentangle behaviors indicative of tactile avoidance and those indicative of the quality of the parent-child relationship or of social aversion.

The lack of a significant relation between infant negative affect and toddler problem behaviors is in contrast with some prior research, which has found predictive associations between general temperamental negativity and problem behaviors during early childhood

(Garon et al., 2009); however, it is notable that other research has found associations between toddlers' negative affect and problem behaviors during later childhood only (Grant et al., 2009). It is possible that infant negative affect is more strongly associated with problem behaviors in later childhood than in early childhood. This result may also be due to methodological differences. In the current study, we used distinct measures of observed infant avoidance and negative affect, whereas other work has subsumed negative affect under measures of tactile avoidance (Baranek, 1999; Baranek, Foster, & Berkson, 1997; Wiggins et al., 2009) or has used parent report of more general temperamental negativity rather than observed negative affect in response to tactile stimuli during infancy (e.g., Garon et al., 2009). It is important to note that even though avoidance (behaviors that minimized tactile stimulation; looking away from and behaviorally resisting tactile stimuli) and negative affect (facial and vocal cues) were defined in this study as distinct behaviors, they were not mutually exclusive, could co-occur, and were moderately correlated. However, the data analytic approach accounted for the independent contributions of avoidance and negative affect in predicting toddler behaviors. Therefore, avoidance of tactile stimulation, controlling for negative affect, may have reflected a sensory reaction to tactile stimuli independent of distress to novelty or limitations, whereas negative affect, controlling for avoidance, may have reflected affective distress to novelty or distress to limitations. It is possible that negative affect during the Flower Print Task was in response to touch, but despite the fact that avoidance and negative affect were measured during the same interaction task and may not be functionally independent, in the current sample, avoidance during tactile stimulation demonstrated different associations with later behaviors than negative affect.

Although children in the current study experienced somewhat elevated levels of pre- and perinatal risks (Marceau et al., 2013), which have been found to indicate risk for abnormal sensory responses (Crepeau-Hobson, 2009) and symptoms of ASD (Gardener et al., 2009), we found no correlation between the measure of obstetric complications and infants' emotional and behavioral responses to tactile stimulation in the Flower Print Task or with toddlers' autism spectrum behaviors. This difference from previous research may be because many studies linking prenatal environment with abnormal sensory responses and autism spectrum behaviors have examined these associations at older ages (e.g., Crepeau-Hobson, 2009; Schendel et al., 2012), and it is possible that effects of prenatal environment are smaller across infancy and toddlerhood. In addition, prior work has examined associations among prenatal factors, abnormal sensory responses, and autism spectrum behaviors in biological families in which prenatal environment is confounded with postnatal environment and where correlated environmental experiences could strengthen prenatal effects. It is possible that aspects of the parenting environment in adoptive families mitigated potential effects of prenatal risk, an issue we plan to examine in future research with this sample.

Limitations

Although the current study is novel in many respects and findings may have important implications for our understanding of infant behaviors that increase risk for atypical development, particularly in social relationships, the study is not without limitations. First, whereas infants' responses to sensory stimulation have traditionally been assessed using

caregiver reports or by systematically examining infants' behavioral responses during exposure to specific types of sensory stimulation by an examiner (e.g., DeGangi & Greenspan, 1989; Dunn & Daniels, 2002), we measured infants' responses to tactile stimuli during a naturalistic parent-child interaction. Although there are advantages to measuring responses to tactile stimulation within a naturalistic, yet structured social context, we had no control over specific types of touch provided by parents (e.g., light touch versus firm touch; amount of touch used to reassure or soothe infant), and it is possible that infants responded differently to specific types of tactile stimulation. Additionally, parenting behavior that may affect infant sensory responses, such as soothing a distressed infant during exposure to tactile stimuli, was not measured. However, the semi-structured nature of the Flower Print Task may have limited the variability of parenting behaviors, as avoidance and negative affect were measured only when parents were painting the child's hands and feet and pressing them to paper. Future research may shed light on parents' awareness of infant tactile avoidance and parenting behavior that is related to infant tactile avoidance by including both a parent-report measure and an interaction task that allows for the observation of a variety of parenting behaviors during the exchange of touch. Indeed, such work could increase understanding of *how* tactile avoidance negatively influences social interactions.

Because the Flower Print task had never been used to examine sensory responding, we intended for this initial work to be specific to this task to determine whether infants' responses could be reliably measured and whether there were predictive associations between their responses to tactile stimulation and toddler behaviors. However, the use of a single parent-child interaction task that included substantial tactile stimulation for measuring infants' responses to touch could also be viewed as a methodological shortcoming. First, the use of a single task also resulted in a very specific measure of avoidance during tactile stimulation. Indeed, we were unable to examine other patterns of response to sensory input (e.g., sensory underresponsiveness) that may be related to autism spectrum behaviors in the current study, and future research should determine whether these responses also predict later autism spectrum behaviors or other social deficits in early childhood. Second, it is possible that infant behaviors conceptualized as tactile avoidance (e.g., gaze aversion, physical resistance) were directed at parents and reflected the quality of the parent-child relationship or social aversion rather than a sensory response. While measuring infants' responses to tactile stimulation during a parent-child interaction may lead to better understanding of the impact of tactile avoidance on social relationships, future research should make use of both social and non-social paradigms for examining children's responses to touch and should compare avoidance and negative affect in tactile and non-tactile tasks. Such a strategy would help to disentangle behaviors indicative of tactile avoidance and those indicative of the quality of the parent-child relationship or of social aversion. Following this initial work on the predictive associations between infants' responses to tactile stimulation during the Flower Print Task and toddler behaviors, we intend to compare infants' responses during the Flower Print Task with their behaviors during other types of tasks to further clarify infant behaviors that predict a range of early childhood outcomes.

In addition, the association between infant avoidance behaviors and toddler autism spectrum behaviors was small, which could be due to the different methods used for measuring infant and toddler behavior (observational versus parent reports) and to the use of a normative sample. It is also notable that prior studies suggest that it is not just one behavior, but rather a constellation of subtle infant behaviors that are predictive of later autism spectrum behaviors (Tager-Flusberg, 2010). However, it is important to note that: 1) the effect we found emerged in a community sample, not one that was recruited for heightened risk for autism or other social deficits; 2) infant avoidance was able to be observed during a structured, yet typical, parent-child interaction versus a standardized assessment by a professional; and 3) the effect was independent of infants' negative affect observed during tactile stimulation. Future research can build on these findings to elucidate the role (e.g., cause, correlate, early manifestation) tactile avoidance may or may not play in the development of autism spectrum behaviors and other social deficits.

Conclusions and Future Directions

The current study makes a significant contribution to research on the importance of touch for infant social development. The experience of touch is critical for early communication and social interaction (Feldman et al., 2002; Field, 2010; Main & Stadtman, 1981), and as our findings suggest, avoidant responses to touch during infancy may specifically predict deficits in social development, such as autism spectrum behaviors. Moreover, our findings showed that it was the behavioral avoidance of tactile stimulation, not negative affect in response to novel or distressing situations that was linked to later autism spectrum behaviors. It may be that infants' avoidance of touch limits their opportunities for engaging in social interactions and for developing higher-order social skills that are largely non-tactile (e.g., verbal communication, emotional responsiveness and understanding). For instance, when a parent uses touch to initiate eye contact or communicate affection or reassurance, the infant who avoids this touch may miss out on affective exchanges with her parent, thus limiting the development of her ability to respond to and understand others' emotions.

It is also possible that tactile avoidance is an early manifestation or simply a correlate of autism spectrum behaviors and is not involved in causal pathways. This is an interesting possibility, particularly in light of the high prevalence of abnormal sensory responses in children with ASD (Tomchek & Dunn, 2007), which has received increased attention in recent years. For instance, abnormal sensory response was recently included in diagnostic criteria for ASD in the *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition* (*DSM-V;* American Psychiatric Association, 2013). However, it is important to note that only one of the children in the current sample fell in the clinical range of the PDP scale. Therefore, research examining whether tactile avoidance differentially predicts ASD symptoms and ASD diagnosis determined from a standardized assessment instrument (e.g., Autism Diagnostic Observation Schedule; Lord et al., 2012), in high-risk (e.g., siblings of children with ASD) and clinical samples must be carried out to shed further light on the role tactile avoidance may play in the development of ASD and, more broadly, social development.

Future research examining pathways between tactile avoidance and social deficits, as well as genetic and parenting factors that may affect these pathways, will also help to clarify the role of tactile avoidance in social development. For instance, the association between infant tactile avoidance and later social deficits may be greater when genetic risks are also present. Further, parents may be able to mitigate the possible negative effects of tactile avoidance on child social development by finding ways to increase infant engagement with touch in their physical environments and social relationships. Overall, findings suggest that incorporating measures of responses to touch in the study of early social interaction may provide an important and discriminating construct for identifying young children at greater risk for social impairments related to autism spectrum behaviors.

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Table 1

CBCL PDP Scale Items.

Item
Afraid to try new things
Avoids looking others in the eye
Can’t stand having things out of place
Disturbed by any change in routine
Doesn’t answer when people talk to him/her
Doesn’t get along with other children
Repeatedly rocks head or body
Seems unresponsive to affection
Shows little affection toward people
Speech problems
Strange behavior
Upset by new people or situations
Withdrawn, doesn’t get involved with others

Table 2

Descriptive Statistics for Study Variables.

Variable	Range	Mean	*SD*
Percent Gaze Away	.00 – .91	.21	.14
Percent Resistance	.00 – .35	.07	.06
Percent Negative Affect	.00 – 1.00	.40	.28
PDP T-score	50.00 – 71.00	52.35	3.42
Internalizing T-score	29.00 – 69.50	43.62	6.97
Externalizing T-score	30.00 – 70.00	47.77	7.16

Table 3

Correlations among Study Variables.

Variable	1	2	3	4	5	6
1. Household Income	--					
2. Obstetric Problems	−.01	--				
3. Avoidance Behaviors	−.10*	.06	--			
4. Negative Affect	.02	.03	.30**	--		
5. PDP T-Score	.02	−.01	.15**	.03	--	
6. Internalizing T-Score	−.05	.00	.07	.05	.64**	--
7. Externalizing T-score	−.05	−.01	.05	.10*	.32**	.61**

Note.

* $p < .05$.

** $p < .01$.

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Table 4

Hierarchical Linear Regression Predicting PDP Scores.

	Final Model		
Variable	***B***	***SE B***	***β***
Internalizing T-score	.33	.02	.69**
Externalizing T-Score	−.05	.02	−.10*
Negative Affect	−.07	.13	−.02
Avoidance Behaviors	.46	.16	.11**

Note.

* $p < .05$.

** $p < .01$.