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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

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**RESUMEN:** La experiencia del tacto es crítica en la temprana comunicación e interacción social; los infantes que muestran aversión al tacto pudieran estar bajo riesgo de un desarrollo atípico y problemas de conducta. El presente estudio se propuso como meta clarificar las asociaciones de predicción entre las respuestas del infante a las manifestaciones de estímulo táctil y la gama de autismo de los niños pequeños, así como las conductas de internalizar y externalizar. Este estudio midió la tendencia a evitar y el afecto negativo de infantes de 9 meses de edad ( $N = 561$ ; 58% varones) durante una novedosa tarea táctil en la cual los progenitores pintaron las manos y los pies de los infantes presionándolos luego sobre un papel para crear un dibujo. Los reportes de los progenitores en las escalas de Internalización y Externalización de Problemas Penetrantes de Desarrollo (PDP), de la Lista de Conducta del Niño, se usaron para medir la conducta de los niños pequeños a los 18 meses. La observada tendencia del infante a evitar y el afecto negativo estuvieron significativamente correlacionados; sin embargo, la tendencia a evitar predijo subsecuentes puntajes de PDP solamente, independiente del afecto negativo, el cual no predijo ninguna de las conductas de los niños pequeños. Los resultados sugieren que incorporar medidas de respuesta al tacto en el estudio de la temprana interacción social pudiera proveer un esquema importante y discriminante para identificar a niños bajo un más serio riesgo de impedimentos sociales relacionados con las conductas de la gama del autismo.

**Palabras claves:** tacto, desarrollo social, conductas de la gama del autismo

**RÉSUMÉ:** L'expérience du toucher est critique pour la communication précoce et l'interaction sociale; les bébés qui font preuve d'aversion au toucher peuvent être à risque de développement atypique et de problèmes de comportement. Cette étude s'est donné pour but de clarifier les liens de prédiction entre les réactions des bébés aux stimuli tactiles et le spectre de l'autisme dans la petite enfance, les comportements d'internalisation et d'externalisation. Cette étude a mesuré l'évitement et l'affect négatif de bébés de 9 mois ( $N = 561$ ; 58% mâles) durant un nouvel exercice tactile durant lequel les parents peignaient les mains et les pieds des bébés et les pressaient sur du papier pour faire un tableau. Les rapports des parents au moyen des échelles d'internalisation et d'externalisation de la Checklist du Comportement de l'Enfant et des échelles des Problèmes Globaux du Développement (abrégé PDP en anglais) ont été utilisés pour mesurer les comportements des jeunes enfants à 18 mois. L'évitement observé et l'affect négatif de l'enfant ont eu une corrélation forte. Cependant, l'évitement a seulement prédit les scores PDP, sans lien avec l'affect négatif, qui n'a prédit aucun comportement du jeune enfant. Les résultats suggèrent que le fait d'incorporer des mesures de réactions au toucher dans l'étude de l'interaction sociale précoce peut offrir une construction importante et unique pour l'identification des enfants à grand risque d'impairment social lié aux comportements du spectre de l'autisme.

**Mots clés:** toucher, développement social, comportements du spectre de l'autisme

**ZUSAMMENFASSUNG:** Das Erfahren von Berührung ist von entscheidender Bedeutung für die frühe Kommunikation und soziale Interaktion; bei Säuglingen, die eine Abneigung gegen Berührungen zeigen, kann ein erhöhtes Risiko für eine atypische Entwicklung und Verhaltensprobleme bestehen. Die aktuelle Studie zielte darauf ab, prädiktive Zusammenhänge zwischen Reaktionen von Säuglingen auf taktile Reize und Autismus-Spektrums-, Internalisierungs- und Externalisierungsverhaltensweisen im Kleinkindalter zu klären. Diese Studie erfasste das Vermeidungsverhalten und den negativen Affekt von 9 Monate alten Säuglingen ( $N = 561$ ; 58% männlich) während einer neuartigen taktilen Aufgabe, indem die Eltern den Säuglingen Hände und Füße anmalten und auf Papier drückten, um ein Bild zu gestalten. Elterliche Berichte bezüglich tiefgreifender Entwicklungsprobleme (Pervasive Developmental Problems, PDP), sowie die Internalisierungs- und Externalisierungs-Skalen der Child Behavior Checklist wurden verwendet, um die Verhaltensweisen der Kleinkinder nach 18 Monaten zu messen. Beobachtete Vermeidung und negativer Affekt beim Säugling waren signifikant miteinander korreliert; jedoch sagte nur die Vermeidung (unabhängig vom negativen Affekt) die späteren PDP Werte vorher. Negativer Affekt sagte keine Verhaltensweisen der Kleinkinder vorher. Die Ergebnisse weisen darauf hin, dass Reaktionen auf Berührung beim Erforschen früher sozialer Interaktion ein wichtiges und unterscheidendes Konstrukt zur Identifizierung von Kindern mit höherem Risiko für soziale Beeinträchtigungen, die mit Autismus-Spektrum-Verhaltensweisen in Verbindung stehen, darstellen können.

**Keywords:** Berührung, soziale Entwicklung, Autismus-Spektrum-Verhaltensweisen

**抄録:** タッチの経験は早期のコミュニケーションと社会的相互交流に決定的に重要である。タッチに嫌悪を示す乳児は、非定型的な発達と行動上の問題のリスクがあるだろう。この研究は、触覚刺激への乳児の反応と、自閉症スペクトラム、内在化問題および外在化問題との間の予測的な関係を明らかにすることを目的にした。この研究では、新しい触覚の課題、すなわち親が乳児の手と足に絵の具を塗り、それを紙に押しつけて絵を作る、をしている間の、月齢9ヶ月の乳児( $N = 561$ ; 58% 男児)の回避と否定的な感情を測定した。広汎性発達問題Pervasive Developmental Problems (PDP)、児童行動チェックリストの内在化尺度と外在化尺度についての親の報告が、18ヶ月時の幼児の行動を測定するために使われた。乳児に観察された回避と否定的感情は、有意に相関した。しかし、回避は後のPDP点だけを予測し、否定的感情とは独立だった。否定的感情は、どんな幼児の行動も予測しなかった。所見は、早期の社会的相互交流の研究に、タッチへの反応の測定を加えることが、自閉症スペクトラム行動に関係する社会的な障害へのより大きなリスクをもつ子どもを見つけるための、重要で識別力のある構成要素を提供するだろうと、示唆する。

**キーワード:** タッチ, 社会性の発達, 自閉症スペクトラム行動

**摘要:** 觸摸的經驗是早期溝通和社會交往的關鍵;厭惡觸摸的嬰兒可能會有非典型發展和行為問題的風險。這次的研究旨在闡明嬰兒對觸覺刺激的反應與幼兒自閉症類、內化和外化行為的預測關係。本研究測試9個月大的嬰兒( $N = 561$ ; 58%男性)在一個新的觸覺任務中的迴避

和負面情緒，父母在嬰兒手和腳塗上顏料，並將其手腳壓在紙上，來做一幅圖畫。家長用兒童行為檢查表(Child Behavior Checklist)中的廣泛性發育問題(Pervasive Developmental Problems; PDP)，內化以及外化量表來衡量幼兒18個月時的行為。在觸覺任務中觀察到的嬰兒迴避和負面情緒有顯著的相關；然而，只有迴避預測後來的PDP得分，負面情緒不能預測任何幼兒的行為。調查結果表明，在早期社會互動的研究中，加入觸摸測試，能提供重要和區別概念，來鑑別有自閉症類行為有關的社會障礙高風險的兒童。

**關鍵詞：** 觸摸，社會發展，自閉症類行為

**ملخص:** تجربة اللمس تعتبر أساسية في التواصل المبكر والتفاعل الاجتماعي وذلك حيث أن الرضع الذين يظهرون تجنباً لللمس ربما يكونون في مخاطرة وجود مشكلات نمو واضطرابات سلوكية. تهدف هذه الدراسة إلى توضيح الارتباطات التنبؤية بين استجابات الرضع لبواصع اللمس وأعراض التوحد وسلوكيات الاستيعاب الداخلي والسلوكيات الخارجية. قامت هذه الدراسة بتقييم حالات التجنب والانفعالات السلبية لدى الرضع عمر 9 شهور (561 رضيع بنسبة 58% ذكور) أثناء القيام بمهمة لمسية جديدة يقوم الآباء فيها بتلويين أيدي أطفالهم وأرجلهم ثم ضغطها إلى ورقة لعمل صورة. تم استخدام تقارير الآباء حول مشاكل النمو والسلوك الاستيعابي والخارجي وذلك لقياس سلوكيات الأطفال في عمر الحبو 18 شهر. وتبين الارتباط الإحصائي بين السلوك التجنبي وبين الانفعالات السلبية ومع ذلك ثبت أن التجنب يتنبأ بدرجات مقياس مشكلات النمو فقط بغض النظر عن الانفعالات السلبية والتي لم تكن مرتبطة إحصائياً بأى سلوكيات لدى الأطفال. ونفذ النتائج أن إدماج مقاييس الاستجابة لللمس في دراسة التفاعل الاجتماعي المبكر ربما يقدم منظومة مهمة ومحددة للتعرف على الأطفال الذين يقعون تحت طائلة مخاطرات أكبر للإعاقة الاجتماعية المرتبطة بسلوكيات التوحد.

**كلمات مفتاحية:** اللمس – النمو الاجتماعي – سلوكيات التوحد

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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 nonhuman animals, social touch (e.g., 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 underresponsiveness) 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 nonhuman primates (Brandt, Baysinger, & Mitchell, 1972; Harlow & Harlow, 1962; Main & Stadtman, 1981); these *autism spectrum behaviors*<sup>1</sup> (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 (e.g., 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 that have suggested 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 nonclinical 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 also has 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

<sup>1</sup>When studied in nonclinical samples, behaviors characteristic of ASD have been called, variously, *autism behaviors*, *autistic traits*, *autistic-like behaviors*, and *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.

behaviors may be indicative of greater social impairment. The current study expanded on prior research that has found links between 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). Regarding touch avoidance, an infant with a tendency to avoid touch from caregivers may receive fewer social initiations and less positive responses from parents and also may 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 also is 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, to our knowledge, 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, gaz-

ing 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 and externalizing as well as autism spectrum behaviors in prior research (Ben-Sasson & Carter, 2013; Bron, van Rijen, van Abeelen, & Lambregtse-van den Berg, 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 also have been found at this age (Baranek, 1999; Lipscomb et al., 2012), although note 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, although note 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, Midwest, and Mid-Atlantic regions of the United States. Each adoption triad consisted of the adopted child, adoptive parents, and at least one birth parent (for detailed information on recruitment and assessment procedures and detailed sample information, see Leve et al., 2013). 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 also would 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% of the children were female. The current investigation included data collected from the adoptive parents and children when the 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:  $mdn = \$124,917$ ,  $SD = \$101,729$ , 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 ( $SD = 5.90$ , range = 26.29–60.55) years, 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 one 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 one race = 1.3%). Approximately 2.2% of adoptive mothers and 1.3% of adoptive fathers were Hispanic. On average, adoptive parents had been married for 11.10 ( $SD = 5.08$ , range = .76–26.26) years. 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) years, and although the sample of birth parents was more racially diverse than that of

the 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 one race = 4.8%, unknown/did not report = 0.2%), and approximately 6.3% 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 who were 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 2½-hr birth mother assessment was completed in the home or some other convenient site at 4 months, and 2½-hr- to 3½-hr adoptive family assessments took place in the home at infant ages 9 and 18 months. Adoptive parents independently completed several tasks 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 coparenting 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.

**TABLE 1.** Child Behavior Checklist Pervasive Developmental Problems 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

Infant behaviors and affect were microcoded 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  $\kappa$ s for each category ranging from .80 to .84 demonstrated high interrater 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.

**TABLE 2.** Descriptive Statistics for Study Variables

Variable	Range	<i>M</i>	<i>SD</i>
%Gaze Away	.00–.91	.21	.14
%Resistance	.00–.35	.07	.06
%Negative Affect	.00–1.00	.40	.28
Pervasive Developmental Problems <i>t</i> score	50.00–71.00	52.35	3.42
Internalizing <i>t</i> score	29.00–69.50	43.62	6.97
Externalizing <i>t</i> score	30.00–70.00	47.77	7.16

### 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 scale of 0 (*not true*), 1 (*sometimes true*), and 2 (*very true*). Specifically, the 13-item PDP (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 nonclinical 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 5 children were in the borderline clinical range, and parent ratings for 1 child were in the clinical range. The CBCL shows good reliability and validity (Achenbach & Rescorla, 2000), and prior research has suggested 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, Şipos, Dobrean, & Micluţia, 2013; Sikora et al., 2008). Ratings from adoptive mothers and fathers, which were significantly correlated—Internalizing scale:  $r = .42, p < .001$ ; Externalizing scale:  $r = .42, p < .001$ ; PDP scale:  $r = .32, p < .001$ —were composited for each scale; ratings from a single parent were used when ratings from only one parent were available.

**TABLE 3.** Correlations among Study Variables

Variable	1	2	3	4	5	6
1. Household Income	–					
2. Obstetric Complications	–.01	–				
3. Avoidance Behaviors	–.10*	.06	–			
4. Negative Affect	.02	.03	.30**	–		
5. Pervasive Developmental Problems <i>t</i> Score	.02	–.01	.15**	.03	–	
6. Internalizing <i>t</i> Score	–.05	.00	.07	.05	.64**	–
7. Externalizing <i>t</i> score	–.05	–.01	.05	.10*	.32**	.61**

\* $p < .05$ . \*\* $p < .01$ .

**Obstetric Complications**

Prior research has suggested 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). In addition, 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),

**TABLE 4.** Hierarchical Linear Regression Predicting PDP Scores

Variable	Final Model		
	<i>B</i>	<i>SE B</i>	$\beta$
Internalizing <i>t</i> Score	.33	.02	.69**
Externalizing <i>t</i> Score	–.05	.02	–.10*
Negative Affect	–.07	.13	–.02
Avoidance Behaviors	.46	.16	.11**

\* $p < .05$ . \*\* $p < .01$ .

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 did female infants (males:  $M = .08, SD = .87$ ; females:  $M = -.12, SD = .72$ ). 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 the 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 later 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 a 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 also could 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 care-

giver 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 also is 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 nonsocial 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 nonsocial 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, Bagnell, Chambers, & Stewart, 2009). It is possible that infant negative affect is more strongly associated with problem behaviors in later childhood than in early childhood. This result also may 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). 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 did 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 traditionally have 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 vs. 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. In addition, parenting behavior that may affect infant sensory responses, such as soothing a distressed infant during exposure to tactile stimuli, was not measured. However, the semistructured 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 the 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 also could 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 a better understanding of the impact of tactile avoidance on social relationships, future research should make use of both social and nonsocial paradigms for examining children's responses to touch and should compare avoidance and negative affect in tactile and nontactile 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 vs. parent reports) and to the use of a normative sample. Also note that prior studies have suggested 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, note that (a) the effect we found emerged in a community sample, not one that was recruited for heightened risk for autism or other social deficits; (b) infant avoidance was able to be observed during a structured, yet typical, parent-child interaction versus a standardized assessment by a professional; and (c) 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 nontactile (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 his or her parent, thus limiting the development of the infant's ability to respond to and understand others' emotions.

It also is 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 *DSM-V* (American Psychiatric Association, 2013). However, note that only 1 child 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, also will 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 also are 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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