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Prospective associations between ASD screening scores, parenting stress, and later socio-emotional-cognitive maturity in a community-based birth cohort

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ABSTRACT

Background: Although autism spectrum disorders (ASD) have been associated with developmental outcomes and parenting stress, it is not known how all variables interact with each other. We estimated prospective associations between ASD screening scores at 24 months and socio-emotional-cognitive development at 36 months while considering parenting stress as a potential moderator of the outcome.

Methods: Using the *Conditions Affecting Neurocognitive Development and Learning in Early Childhood* data, ASD-risk behaviors at 24 months and child maturity levels in social, emotional, and cognitive domains at 36 months were reported (N = 1100).

Results: The number of ASD-type behaviors at 24 months was significantly associated with the socio-emotional-cognitive risk index at 36 months (B = .31, p < .01, 95% CI = .24–.38), mother-reported parenting stress at 24 months (B = .77, p < .01, 95% CI = .50–1.03), and maternal education (B = 0.67; p < .01; *95% CI* = .39–.96). Further investigation revealed that children who had higher ASD screening scores and more distressed mothers experienced higher socio-emotional-cognitive risk than their counterparts who had either risk factor or none (p < .01).

Conclusions: ASD screening scores and parenting stress interact together to have an effect on later child developmental competence. This study suggests that interventions towards early ASD symptoms and parenting stress could enhance subsequent child developmental competence, which is a strong building block for early school readiness and personal success.

1. Introduction

In normative populations, not much is known about the degree to which autism spectrum disorder (ASD) symptoms in infancy are associated with subsequent developmental maturity towards the end of toddlerhood. The role of parenting stress as a potentially complementary influence on later developmental outcomes also has yet to be addressed. This would be useful to professionals

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concerned about school readiness on a broader scale. Children reach numerous developmental milestones in various domains in the first few years of life. There are 4 main types of milestones in preschool: social and emotional, language and communication, cognitive, and physical (Centers for Disease Control & Prevention, 2014). A number of factors, including early ASD symptoms and parenting stress, may impact developmental achievements.

ASD symptomatology includes social communication and interaction pathology across multiple contexts, and restricted or negative patterns of behavior, interests, or routines (American Psychological Association, 2013). Past research has used early ASD screenings to estimate symptomatology in population-based samples (Baron-Cohen et al., 2000; Chlebowski, Robins, Barton, & Fein, 2013; Wong et al., 2004). Because early socio-emotional-cognitive impairment is inherent to children with diagnosed ASD symptoms, a better understanding of the association between the number of early ASD symptoms and later levels of socio-cognitive skills would be of interest to researchers and practitioners. Potential findings could strengthen the idea that early ASD symptoms may not result in a diagnosis, but may nevertheless indicate significant later developmental impairment.

Cognitive milestones by 36 months are important building blocks to school readiness by the time children reach kindergarten age preceding formal school entry. In the case of children with early ASD symptoms, a number of developmental milestones have not been met. Over the long term, cognitive impairment might lead to deficits in school readiness, which then forecasts academic achievement by age 22 (Entwisle, Alexander, & Olson, 2005; High, 2008; Pagani, Fitzpatrick, Archambault, & Janosz, 2010). In relation to cognitive and behavioral skills, socio-emotional development also represents an important building block to school readiness.

To estimate developmental maturity by 36 months, socio-emotional milestones must also be considered. The Child Behavior Checklist indicate that preschoolers with ASD have significantly higher scores on the anxious/depressed, withdrawn, attention problems, anxiety problems, and pervasive developmental problems scales compared to typically developing children (Muratori et al., 2011). Those scales reflect poorer socio-emotional maturity in children with ASD. In the long term, functional impairment in socio-emotional skills can also contribute to academic and occupational underachievement (Howlin & Goode, 1998; Howlin, Baron-Cohen, & Hadwin, 1999). Should we look at the association between early ASD symptoms and later developmental maturity, we must also consider the influence of a number of other variables on child developmental outcomes. Hence given that past research has associated parenting stress with developmental impairment, parenting stress could potentially play a moderating role.

Delays in developmental maturity can place a strain on parents. Parents with higher parenting stress levels and factors associated with stress are more likely to see their children display more deficits in language, social, and cognitive skills (Coon, 2007; Magill-Evans & Harrison, 2001). Parenting stress has been associated with both internalizing and externalizing behavior problems in toddlers (Anthony et al., 2005; Baker, Blacher, Crnic, & Edelbrock, 2002; Estes et al., 2013; Hastings et al., 2005). On the other hand, more severe ASD-type behavior problems specifically predict higher parenting stress levels (Huang et al., 2014; Rivard, Terroux, Parent-Boursier, & Mercier, 2014). Furthermore, maternal depression, which is often comorbid with maternal stress, affects early vocabulary regardless of how talkative mothers are with their children (Pan, Rowe, Singer, & Snow, 2005). Even in typically developing populations, children may experience difficulty in socio-emotional development and show dysfunctional behavior if their parents are under stress (Deater-Deckard, 1998; Deater-Deckard & Scarr, 1996). Several studies found that inconsistent and unsupportive parenting styles, which are typically displayed by distressed parents, precede the development of attention problems, lower levels of school readiness, cognitive ability, and social competence in children (Barry, Dunlap, Cotton, Lochman, & Wells, 2005; Campbell & von Stauffenberg, 2008; Hutchison, Feder, Abar, & Winsler, 2016; Jackson, Brooks-Gunn, Huang, & Glassman, 2000; McLoyd, 1998). An association has also been found between distressed parents, providing low levels of cognitive stimulation, and children scoring below average on verbal intelligence and scholastic tests at age 4 and beyond (Nievar & Luster, 2006). However, a bidirectional association has been found between parenting stress and child functioning, of which internalizing and externalizing behaviors were the main interests (Baker et al., 2003; Lecavalier, Leone, & Wiltz, 2006; Orsmond, Seltzer, Krauss, & Hong, 2003; Woodman, Mawdsley, & Hauser-Cram, 2015; Zaidman-Zait et al., 2014). Ideally, a study that uses socio-cognitive maturity as an outcome must consider the influence of parenting stress to prevent any unwanted bias. Hence we should wonder if parenting stress moderates any relationships between individual characteristics and later estimates of child maturity.

Although correlations have been previously established between ASD, parenting stress, and child development outcomes, researchers have yet to investigate whether the actual number of early ASD symptoms and parenting stress interact together to influence subsequent child development in a population-based sample. Using the *Conditions Affecting Neurocognitive Development and Learning in Early Childhood* (CANDLE) birth cohort, the purposes of this study were to: 1) estimate prospective associations between ASD screening scores at 24 months and later child socio-emotional-cognitive maturity at 36 months; 2) estimate the role of parenting stress as an intermediate to the association between ASD screening scores at 24 months on socio-emotional-cognitive outcomes at 36 months. We hypothesized that higher ASD screening scores will predict significantly more risks to child socio-emotional-cognitive maturity, based on past developmental research. Our second hypothesis stated that parenting stress will interact with ASD screening scores and act as a moderator of the association between screening scores and developmental outcomes. As such, higher parenting stress interacting with high ASD screening scores is expected to predict more risks to all the social, emotional, and cognitive scales.

2. Methods

2.1. Participants

Participants were recruited for the *Conditions Affecting Neurocognitive Development and Learning in Early Childhood* (CANDLE) longitudinal birth cohort study in Shelby County, Tennessee. The CANDLE study is designed to examine a wide range of maternal and

Table 1
Descriptive statistics for the predictor, outcomes, and control variables with reference data corrections.

Variable	N	Score range	Mean score	SD
Predictor (24 months; continuous scores)				
Number of M-CHAT items failed (total number)	1100	0 – 10	.69	1.18
Control variables (binary scores)				
Sex of the child	1100	0 – 1	.51	.50
• Boys (coded 1)	544			
• Girls (coded 0)	556			
Maternal education at enrollment	1100	0 – 1	.09	.29
• Did not complete HS (coded 1)	100			
• Completed HS (coded 0)	1000			
Maternal marital status at 12 months	1100	0 – 1	.42	.49
• Single (coded 1)	460			
• Married/Cohabitating (coded as 0)	640			
Maternal ethnic background at enrollment	1100	0 – 1	.64	.48
• African-American (coded 1)	706			
• Caucasian (coded 0)	376			
• Others (coded 0)	18			
Birth weight for gestational age	1100	0 – 1	.07	.26
• Below 10th percentile (coded 1)	81			
• Equal/above 10th percentile (coded 0)	1019			
Intermediate variable (24 months; binary scores)				
Parenting stress percentile	1100	0 – 1	.12	.32
• Equal or over 85th percentile (coded 1)	127			
• Below 85th percentile (coded 0)	973			
Outcomes (36 months; continuous scores)				
Socio-emotional-cognitive risk index	1100	0 – 8	0.95	1.49
Cognitive composite score	1100	55 – 145	96.78	9.94
Receptive communication scaled score	1100	1 – 18	10.22	2.08
Expressive communication scaled score	1100	1 –18	10.10	2.22
Emotionally reactive scale T score	1100	50 – 93	52.61	4.65
Anxious/depressed scale T score	1100	50 – 96	52.28	4.19
Withdrawn scale T score	1100	50 – 94	54.35	6.14
Attention problems scale T score	1100	50 – 80	53.77	5.26
Aggressive behavior scale T score	1100	50 – 100	52.73	5.24

infant characteristics associated with early childhood development from the second trimester of pregnancy to age 60 months. Participating mothers were enrolled between December 2006 and June 2011. Following informed consent, healthy pregnant women in Memphis and Shelby County were recruited at the Regional Medical Center at Memphis, several local hospitals, and health care providers associated with the University of Tennessee Health Science Center (64.0% African-American, 34.2% Caucasian, 1.6% others; Table 1). Data collection was limited to one child per family, and the child had to be born from a single pregnancy. Pregnant women were excluded if they had an existing chronic disease requiring medication, pregnancy complications, prolapsed or ruptured membranes, oligohydraminios, or complete placenta previa. Data was provided by 1100 child-mother dyads for this study. The Institutional Review Board of the University of Montreal and the University of Tennessee Health Science Center, Memphis approved this research.

2.2. Measures

2.2.1. Predictor: ASD screening scores (24 months)

The *Modified Checklist for Autism in Toddlers* (M−CHAT; Robins, Fein, & Barton, 1999) was administered by a trained cognitive examiner, who is either a licensed psychologist or an advanced psychology graduate student, to assess ASD-type child behaviors at 24 months. The scale consists of 23 items with "yes/no" answers. Each answer determines whether there is a possible ASD-type behavior (= 1 for a failed item) or no sign (= 0) according to the answer key. This instrument has good internal consistency (α = .85; Robins, Fein, Barton, & Green, 2001). The M−CHAT has sensitivity and specificity rates of 0.87 and 0.99 respectively in American children (Robins et al., 2001). Greater M−CHAT scores indicate more ASD-type child behaviors, thus greater risk. The screening scores remain as they are for the first part of this study, but are dichotomized for risk for the second part. Although the M−CHAT is failed with a minimum score of 3, risk groups are delineated based on where the screening score for each individual stands in comparison to the mean ASD screening score added by one standard deviation.

2.2.2. Outcome variables: Socio-emotional-cognitive risk (36 months)

The *Bayley Scales of Infant and Toddler Development – Third Edition* (BSID-III; Bayley, 2006) was administered to assess the level of child development in 36-month-olds. In the CANDLE study, children were assessed in 2 key developmental domains: cognition and

language. Each item was scored as 0 or 1, depending on whether the child was able to perform a given task. Raw scores were then converted into scaled scores, which were used to determine the performance of the child in comparison with norms taken from typically developing children of their age (in months). The BSID-III has established reliability, with coefficients ranging between 0.86 and 0.93 for subscales and composite scores (Bayley, 2006).

The *Child Behavior Checklist* for children aged between 18 months and 5 years (CBCL 1½-5; Achenbach & Rescorla, 2000) assesses social, behavioral, and emotional problems in children. The CBCL can be used as a screening tool for a variety of behavioral and emotional problems such as attention deficit, hyperactivity, oppositional-defiance, conduct problem, separation anxiety, social phobia, *etc.* The preschool version of the CBCL consists of 100 questions where the parent answers statements about the child's behavior. Responses range between 0 (Not true), 1 (Somewhat/Sometimes), and 2 (Very true/Often true). Measures yield T-scores for each scale. The CBCL has solid test-retest reliability coefficients, with the majority of those in the 0.80 s and 0.90 s (Achenbach & Rescorla, 2000).

To derive a measure of socio-emotional-cognitive risk, continuous T-scores for emotionally reactive, anxious/depressive, withdrawn, and aggressive behavior, and attention problems scales from the CBCL and scores for the cognitive composite, receptive language, and expressive language scales from the BSID-III were transformed into discrete outcomes. Specifically based on the data distribution for each of the BSID-III and CBCL outcomes, the cutoff point for the cognitive composite, receptive and expressive language scales in the BSID-III was one standard deviation below the mean; anything equal or below the cutoff score was coded as 1 (risk group) while any other score was coded as 0 (low or no risk group). As for the scales from the CBCL, each T-score was coded as 1 (risk group) if equal or exceeding one standard deviation above the mean; any other T-score was coded as 0 (low or no risk group). The dichotomy of a coding was corresponding to lower or higher risk. The risk scores depend on where the child stands in comparison of precise cutoff points for risk of deficits.

A composite socio-emotional-cognitive risk index was then derived using the sum of the eight BSID-III and CBCL characteristics. Thus, socio-emotional-cognitive risk index scores ranged from 0 to 8. An index score seemed more optimal than using clinical cutoffs given the characteristics of the catchment strategy to obtain the predominantly urban-based and underserved CANDLE sample. Specifically, minority-born children tend to score differently from their Caucasian counterparts on both Likert-type scales and the BSID-III (Bachman & O'Malley, 1984; Bachman, O'Malley, & Freedman-Doan, 2009; Duncan et al., 2012). Past research has shown that psychometric challenges arise when some demographic groups and other developmental challenges are involved (Bölte, Westerwald, Holtmann, Freitag, & Poustka, 2011; Moody et al., 2017; Nguyen, Huang, Arganza, & Liao, 2007; Oosterling et al., 2010; Scarpa et al., 2013). Thus, we needed to develop aggregate scores to reflect a more conservative approach for risk analysis.

2.2.3. Intermediate variable: parenting stress (24 months)

The *Parenting Stress Index Short Form* (PSI/SF) derives from the full-length Parenting Stress Index (Abidin, 1995). This self-administered questionnaire evaluates the parenting system and identifies strain that may lead to behavior problems in the child or in the parent. There are 3 major domains of stress: child characteristics, parent characteristics, and situational life stress. The PSI/SF consists of 36 items, rated on a Likert scale between 1 (strongly agree) and 5 (strongly disagree). The test has solid reliability for each separate subscale (α = .78–.88 for the child subscale; α = .75–.87 for the parent subscale) and for test-retest reliability (α = .71 for the parent after 3 weeks; α = .82 for the child after 3 weeks; α = .70 for the parent after 1 year; α = .55 for the child after 1 year). Reliability coefficients for the 2 subscales and the total stress score are 0.96 or greater, indicating high internal consistency (American Psychological Association, 2014). The total stress percentile score was the variable of interest, and was coded to differentiate between mothers with clinically high stress levels (equal or over the 85th percentile = 1) and mothers with normative stress levels (below 85th percentile = 0) with a reference to the cutoff established by the PSI manual (Abidin, 1995).

2.2.4. Control variables: Mother and child (reported at the time of enrollment, at birth, or at 12 months)

Mothers reported on (1) highest academic achievement at the time of enrollment, which was dichotomized by high school diploma or above (coded as 0) or no high school diploma (coded as 1); (2) ethnic background (non-African-American coded as 0; African-American coded as 1); (3) marital status at the time the child was 12 months old. The variable was coded to differentiate between mothers married/cohabitating mothers (coded as 0) and single mothers (coded as 1).

Using the information from the labor and delivery form, girls were coded "0″ while boys were coded "1″. Data on percentile for birth weight for gestational age value was registered in the neonatal summary form. It determines whether or not the child is small for their gestational age (SGA) based on American intrauterine gender-specific growth curves (Olsen, Groveman, Lawson, Clark, & Zemel, 2010). Using the recommended cutoff point for SGA, weights below the 10th percentile were coded as 1 while percentiles equal or above the 10th percentile were coded as 0.

2.2.5. Data analytic strategy

The contribution of M−CHAT scores in predicting later socio-emotional-cognitive risk was subsequently assessed using least squares linear regression. A number of mother and child characteristics were included as control for possible confounders, competing explanations, and omitted variable bias. Consequently, all regression models were adjusted for maternal education, maternal ethnic background, maternal marital status, sex of the child, birth weight for gestational age, and parenting stress.

To assess parenting stress as a potential moderator of the association between M−CHAT scores and subsequent developmental outcomes, we created an interaction variable with participants divided into 4 categories depending of their M−CHAT scores and mother-reported parenting stress levels. The cutoff point for the M−CHAT was one standard deviation above the mean, which meant that scores equal or above the cutoff were coded as 1 (high M−CHAT). Scores below the cutoff were coded as 0 (low M−CHAT). For

the total stress score in the PSI/SF, the cutoff point was the 85th percentile stress score, which means that any score equal or above the cutoff would be 1 (high PSI); any score below the cutoff would be 0 (low PSI). The use of the 85th percentile stress score was done with respect to the clinical threshold on the PSI. As a result, we created 4 groups that differed on the level of risk: one high-risk group (high M−CHAT, high PSI), two intermediate-risk groups (high M−CHAT, low PSI; low M−CHAT, high PSI), and one low-risk group (low M−CHAT, low PSI). We then tested the interaction by using the Tukey post-hoc test to compare mean socio-emotional-cognitive risk index scores. Participants who have low M−CHAT scores and low mother-reported parenting stress levels are considered as our low-risk reference group.

This longitudinal study required numerous data sources and follow-ups. As such, we expected children to have a percentage of incomplete data, at random, on one or more variables. Incomplete data percentages ranged from 0.09% to 12.00%. Missing data may potentially bias estimated associations regardless of what analysis method is used, especially with a little more than 120 children without BSID-III nor CBCL data at 36 months (*online appendix*). Thus multiple imputation corrects for attrition bias while increasing precision (Cummings, 2013). Thus, we estimated randomly distributed incomplete data by conducting multiple imputation using SPSS statistical analysis software. A total of 100 databases were created with imputed data and then merged into one database. All average imputed values that had decimals have been rounded to the nearest unit score when they should have no decimals. Then all analyses have been performed on the newly merged and corrected database.

3. Results

Table 1 reports descriptive statistics for the predictors (as an index and by components), outcome, and control variables. At 24 months, children failed 0.69 items on average on the M−CHAT (SD = 1.18; range 0–10). At 36 months, children had average scores of 96.78 (SD = 9.94) for the cognitive composite scale, 10.22 (SD = 2.08) for receptive language, 10.10 (SD = 2.22) for expressive language, 52.61 (SD = 4.65) for the emotionally reactive scale, 52.28 (SD = 4.19) for the anxious/depressive scale, 54.35 (SD = 6.14) for the withdrawn scale, 53.77 (SD = 5.26) for attention problems, and 52.73 (SD = 5.24) for aggressive behavior. The resulting socio-emotional-cognitive risk index scored 0.95 points on average (SD = 1.49).

Table 1 did not, however, indicate the most recurrent M−CHAT questions that have been failed. Items 8 ("*Can your child play properly with small toys without just mouthing, fiddling, or dropping them?*"; no = fail; N = 39), 18 ("*Does your child make unusual finger movements near his/her face?*"; yes = fail; N = 88), and 22 ("*Does your child sometimes stare at nothing or wander with no purpose?*"; yes = fail; N = 132) are the most recurrent symptoms of repetitive or restricted behavior. Items 19 ("*Does your child try to attract your attention to his/her own activity?*"; no = fail; N = 34), 17 ("*Does your child look at things you are looking at?*"; no = fail; N = 37), and 23 ("*Does your child look at your face to check your reaction when faced with something unfamiliar?*"; no = fail; N = 40) come up as the most recurrent symptoms of social deficits. Item 1 ("*Does your child enjoy being swung, bounced on your knee, etc.?*"; no = fail; N = 41) could either reflect a difficult child temperament or sensitivity issues with environmental stimuli.

Table 2 reports descriptive statistics on the number of children with an ASD diagnosis, at least one different psychiatric diagnosis, and at least two confirmed psychiatric diagnoses for each possible socio-emotional-cognitive risk score according to the CANDLE Health, Medication, and Diagnosis Questionnaire (HMDQ) that was administered by age 60 months. Out of 1100 children, 12 were diagnosed with ASD – 11 of whom met risk scores of 3 or higher. Regarding other conditions, 82 of the 1100 children were diagnosed with at least major depressive disorder (N = 1), general anxiety disorder (N = 7), attention deficit with hyperactivity disorder (N = 9), learning disability (N = 9), conduct disorder (N = 17), and/or communication disorder (N = 59). The majority of participants diagnosed with at least one diagnosis other than ASD had risk scores of 3 or lower (N = 61). A total of 18 children received at least two diagnoses. Nevertheless, the distribution of risk scores did not reveal any pattern that suggests an increase in the odds of receiving more than one diagnosis. Of the 173 children who scored at least one standard deviation above the mean on the M−CHAT (raw score ≥ 2), a diagnosis of ASD was given to 8 children while 10 had more than one confirmed diagnosis.

Table 3 reports bivariate correlations between predictors, outcome, and control variables. Based on our results, increases in M−CHAT scores are associated with subsequent higher socio-emotional-cognitive risk index scores ($r_s = 0.25$; $p < .01$). When risk index components were addressed individually, increases in M−CHAT scores were associated with higher CBCL T scores in the

Table 2
Descriptive statistics for diagnostic outcomes by socio-emotional-cognitive risk scores at 36 months. Diagnostic outcomes include the number of cases with an ASD diagnosis, with at least one diagnosis other than ASD, and with at least two diagnoses according to the CANDLE HMDQ by 60 months.

Socio-emotional-cognitive risk		Cases with ASD diagnoses	Cases with other diagnoses	Cases with at least 2 diagnoses
Score	Percentage			
0	58.6%	1	24	3
1	17.3%	0	17	1
2	9.5%	0	9	3
3	6.8%	3	11	3
4	3.3%	1	5	1
5	2.7%	3	10	4
6	1.2%	3	5	2
7	.5%	1	1	1
8	.2%	0	0	0

Table 3
Bivariate correlation matrix between predictor, outcomes, and control variables with reference data corrections.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1) Number of M-CHAT items failed	1.00															
2) Socio-emotional-cognitive risk index score	.25***	1.00														
3) Cognitive composite score	−.24***	−.46***	1.00													
4) Receptive communication score	−.24***	−.48***	.70***	1.00												
5) Expressive communication score	−.21***	−.46***	.66***	.74***	1.00											
6) Emotionally reactive scale T score	.13***	.44***	−.06	−.04	-.08*	1.00										
7) Anxious/depressed scale T score	.18***	.43***	−.18***	−.12***	−.15***	.58***	1.00									
8) Withdrawn scale T score	.20***	.45***	−.23***	−.18***	−.26***	.50***	.49***	1.00								
9) Attention problems scale T score	.15***	.44***	−.20***	−.19***	−.18***	.44***	.39***	.38***	1.00							
10) Aggressive behavior scale T score	.09**	.46***	-.09**	-.09**	−.11***	.63***	.52***	.46***	.57***	1.00						
11) Sex of the child	.05	.06*	−.16***	−.16***	−.18***	−.02	−.03	−.02	.06	.03	1.00					
12) Maternal education	.11***	.19***	−.18***	−.16***	−.20***	.07*	.16***	.16***	.10***	.08**	.02	1.00				
13) Maternal marital status	.17***	.14***	−.29***	−.28***	−.24***	.00	.09**	.02	.13***	.05	−.02	.17***	1.00			
14) Maternal ethnic background	.17***	.12***	−.37***	−.39***	−.33***	−.08**	.01	.07*	−.01	−.02	.02	.14***	.49***	1.00		
15) Birth weight for gestational age	.02	.09**	−.14***	−.08**	−.05	.02	.09**	.03	.04	.03	.04	.06	.09**	.09**	1.00	
16) Parenting stress percentile	.26***	.25***	-.13**	-.15***	-.12***	.24***	.13***	.22***	.22***	.26***	.01	.09**	.14***	.09**	.04	1.00

Notes: asterisks reflect level of significance: * $p \leq .05$; ** $p \leq .01$; *** $p \leq .001$. Spearman correlations are used for variables 1–10. Pearson correlations are used for variables.11–16.

Table 4
Unstandardized and standardized coefficients for the adjusted relationship between the number of failed items on the M−CHAT at 24 months and the socio-emotional-cognitive risk index at 36 months with reference data corrections.

Predictor	Unstandardized coefficients		95% CI		Standardized coefficients
	B	SE	Lower	Upper	
Number of failed M-CHAT items	.31**	.04	.24	.38	.25
Sex of the child	.14	.08	−.03	.30	.05
Maternal education	.67**	.15	.39	.96	.13
Maternal marital status	.10	.10	−.09	.29	.03
Maternal ethnic background	.06	.10	−.13	.26	.02
Birth weight for gestational age	.36*	.16	.04	.67	.06
Parenting stress percentile	.77**	.14	.50	1.03	.16
R square	.16				

Note: * p ≤ .05; ** p ≤ .001.

emotionally reactive (r_s = 0.13; $p < .01$), anxious/depressed (r_s = .18; $p < .01$), withdrawn (r_s = .20; $p < .01$), aggressive behavior (r_s = 0.09; $p < .01$), and attention problems scales (r_s = 0.15; $p < .01$). Increases in M−CHAT scores were also linked with lower BSID-III scores in the cognitive composite (r_s = -0.24; $p < .01$), receptive (r_s = -0.24; $p < .01$), and expressive communication scales (r_s = -0.21; $p < .01$). Socio-emotional-cognitive risk was significantly higher in cases where mothers did not finish high school (r = 0.19; $p < .01$), who were single (r = 0.14; $p < .01$), of African-American descent (r = 0.12; $p < .01$), who had parenting stress levels equal or above the 85th percentile (r = 0.25; $p < .01$), or when children were born with a low birth weight (r = 0.09; $p < .01$). Male children were also at risk of having higher risk index scores compared to girls. Although significant (p = .04), the bivariate relationship is extremely modest (r = 0.06).

3.1. Prospective associations between ASD screening scores and later child developmental maturity

Table 4 presents the unstandardized coefficients of the least squares linear regression model for the adjusted relationship between the number of total failed items on the M−CHAT at 24 months and the socio-emotional-cognitive risk index at 36 months. An increase in the M−CHAT score corresponded to a 24.5% increase in the risk index score (B = .31; $p < .01$; *95% CI* = .24–.38). A number of control variables (maternal education, weight for gestational age, and mother-reported parenting stress) uniquely predicted a significant proportion of the variance. The risk index score is increased by 13.0% (B = 0.67; $p < .01$; *95% CI* = .39–.96) in mothers without a high school diploma compared to mothers who completed high school. Risk index scores are increased by 6.2% (B = .36; p = .03; *95% CI* = .04–.67) in children who were born SGA compared to peers who had birth weight within normal ranges. Finally, mother-reported parenting stress predicted a 16.4% (B = .77; $p < .01$; *95% CI* = .50–1.03) increase of the risk index score.

3.2. Estimating the role of parenting stress as an intermediate

Finally, we analyzed for a potential moderating influence of parenting stress at 24 months on the main association between M−CHAT scores and subsequent socio-emotional-cognitive risk scores. Table 5 reports descriptive statistics regarding the number of participants and mean socio-emotional-cognitive scores for each of the 4 groups created by the interaction between ASD screening scores and parenting stress levels. A total of 48 participants are categorized as high-risk while 224 participants met criteria for an intermediate risk. Nevertheless, the majority of participants (N = 848) belong to the low-risk group. When testing the interaction that included M−CHAT scores and parenting stress scores, the Tukey procedure revealed significant differences in socio-emotional-cognitive risk index scores. The high-risk group (high M−CHAT, high PSI) scored higher than the low-risk reference group (low M−CHAT, low PSI) by an average of 1.73 risk index points ($p < .01$). Also, the high-risk group scored significantly higher than both intermediate-risk groups by averages of 1.04 (high M−CHAT, low PSI; $p < .01$) and .76 (low M−CHAT, high PSI; p = .02) respectively. Finally, the low-risk reference group had significantly lower scores than both intermediate-risk groups by respective

Table 5
Descriptive statistics for number of participants and average socio-emotional-cognitive child risk scores, according to the interaction of child M−CHAT scores with parent scores on the PSI/SF.

Interaction variable groups	N	Valid %	Socio-emotional-cognitive risk index	
			Mean	SD
High M-CHAT, high PSI	48	4.36	2.458	2.031
Low M-CHAT, low PSI	848	77.09	.728	1.297
Low M-CHAT, high PSI	79	7.18	1.696	1.697
High M-CHAT, low PSI	125	11.36	1.416	1.770

Note: high M−CHAT ≥ 1.87; low M−CHAT < 1.87; high PSI ≥ 85th percentile; low PSI < 85th percentile.

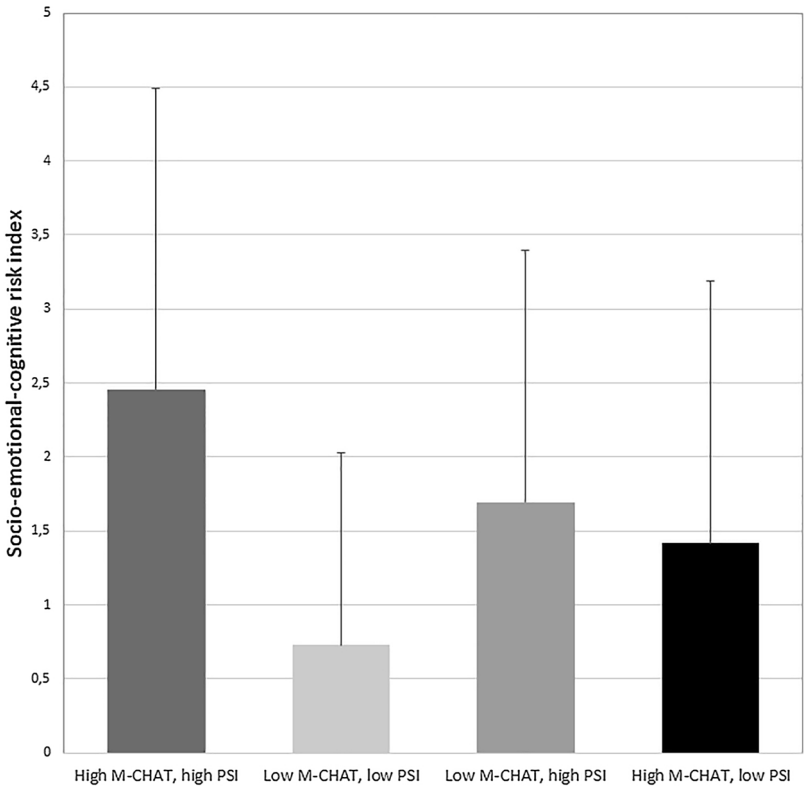

Fig. 1. Interaction effects of ASD screening and parenting stress.

averages of -.69 (high M−CHAT, low PSI; $p < .01$) and -.97 (low M−CHAT, high PSI; $p < 0.01$). Fig. 1 illustrates this moderation effect on socio-emotional-cognitive risk index scores.

4. Discussion

This study sought to examine prospective associations between ASD screening scores at 24 months and subsequent maturity risks at 36 months in a population-based sample. We analyzed as whether the actual number of early ASD symptoms could lead to more socio-emotional-cognitive deficits. At the same time, we examined the possibility that parenting stress might interact with the number of early ASD symptoms to influence socio-emotional-cognitive outcomes at 36 months.

Past research has suggested that children with ASD have lower scores on social, emotional, and cognitive scales on various tests (Bayley, 2006; Long, Gurka, & Blackman, 2011; Muratori et al., 2011). Previous research has also associated parenting stress with dysfunctional child behavior (Deater-Deckard, 1998; Deater-Deckard & Scarr, 1996). However, these studies have involved children diagnosed with ASD instead of population-based samples. Our population-based 1110 child-mother dyads have diagnostic prevalence rates that are mostly inferior to those that were found in various studies from the last decade (American Speech-Language-Hearing Association, 2015; Anxiety & Depression Association of America, 2016; Boat & Wu, 2015; Centers for Disease Control & Prevention, 2014; Lader, 2015; Wichstrøm et al., 2011). Conduct disorder is the only condition that has a higher prevalence rate than what was found in the literature.

In this longitudinal study, we found that ASD screening scores significantly predicted later socio-emotional-cognitive risk. Parenting stress also holds a significant moderating effect on the main association. As expected, higher child ASD screening scores at 24 months predicted increased subsequent socio-emotional-cognitive risk index scores at 36 months. Above and beyond the influence of control variables, ASD screening scores made the most important relative contribution in predicting socio-emotional-cognitive risk. This relationship remained significant both in children whose mothers had parenting stress scores above or equal to the 85th percentile, and in children whose mothers had parenting stress levels below the 85th percentile. This suggests a strong link between results on the M−CHAT and the content of socio-emotional-cognitive risk among children. ASD was diagnosed for 8 children while 10 received at least two diagnoses among the 173 children who scored at least one standard deviation above the mean in ASD screening. This finding confirms the importance of conducting an in-depth clinical evaluation of higher scores, especially beyond one standard deviation, on this screening instrument. Remarkably, general demographic factors consistently played a role in predicting socio-emotional-cognitive risk.

Other control variables (maternal education, and birth weight for gestational age) and the intermediate variable (parenting stress) were also found to make unique contributions in predicting socio-emotional-cognitive risk despite being reduced to binary scores.

Based on the results, socio-emotional-cognitive risk was likely to be higher in children who were born small for gestational age, whose mothers did not finish high school, and whose mothers scored over the 85th percentile on parenting stress. Two studies on response patterns on Likert scales suggested that African American participants are far more likely than their counterparts from other ethnic groups to use extreme response categories on Likert scales (Bachman & O'Malley, 1984; Bachman et al., 2009). However, it is possible that the tendency to provide more extreme responses on tests that use rating scales has to do with mothers who achieved a lesser level of education instead, especially when maternal ethnicity was controlled. Our results could be regarded as corroborating or extending the findings by Carneiro, Meghir, and Parey (2013), who associate lower maternal education with poorer cognitive development outcomes at 7 to 8 years of age. Meanwhile, modest but significant results found in weight for gestational age at birth support past research claiming that children born small for their gestational age have marginally impaired cognitive development in early childhood (Sommerfelt et al., 2000).

Davis and Carter (2008) found that parents of children aged 33 months and younger reported elevated parenting stress when facing child behavior that is associated with ASD. As such, we already supposed an interaction to exist between early ASD symptoms and parenting stress. In our sample, the interaction between early ASD behavior and parenting stress produced distinctive differences between groups on socio-emotional-cognitive risk. Children belonging to the high-risk group, which comprised high ASD screening (high M−CHAT; score $\geq$ 2) and high parental stress (high PSI) scores, were more likely to show increased socio-emotional-cognitive risk than children from the low-risk or intermediate-risk groups. Comparing groups with higher ASD screening scores, the high-risk group (high M−CHAT, high PSI) still showed increased risk than the intermediate-risk group (high M−CHAT, low PSI). Among those with low ASD screening scores, children with more distressed mothers (high PSI) showed higher socio-emotional-cognitive risk than their counterparts with less distressed mothers (low PSI). These results suggest that early ASD behavior and parenting stress interact with one another to moderate developmental maturity. With the body of research supporting a bidirectional association between parenting stress and child development (Baker et al., 2003; Lecavalier et al., 2006; Orsmond et al., 2003; Woodman et al., 2015; Zaidman-Zait et al., 2014), the interaction between early ASD symptoms and parenting stress becomes a more delicate issue. In clinical assessments and interventions, practitioners need to assess child symptoms in the context of perceived parenting stress, especially socio-emotional-cognitive risk given the bidirectional influence between child behavior and parental emotional state.

4.1. Limitations

This study has some limitations. The main limitation is the use of subjective data from mothers as the main predictors. First, the combined use of the M−CHAT and its follow-up interview has been found to increase sensitivity, and improves positive predictive value from 36% to 74% (Kleinman et al., 2008). That finding is corroborated in a different study in which M−CHAT positive predictive value increased from 6% to 54% for ASD and from 11% to 98% for any diagnosis with developmental concerns that warrant intervention (Chlebowski et al., 2013). Therefore, the current study might not provide a precise level of individual ASD symptomatology because the follow-up clinical interview procedure was not administered to provide some subjectivity control. Considering that the cutoff between high and low M−CHAT groups stands between raw scores of 1 and 2, a lack of accuracy in ASD screenings may take participants into the wrong group. Hence, the clinical utility of the M−CHAT in detecting the number of early symptoms may be questionable. Second, the individual items in the M−CHAT have dichotomized answers that indicate the absence or presence of early ASD symptoms. However, the intensity of those individual symptoms remains unknown. Therefore, our interpretations could not benefit from a more complete quantitative indicator that respects criteria for ASD. Finally, language skills were assessed rather severely in the BSID-III where every mistake means failure, and thus children who are exposed to less English words may not perform up to expectations. The use of more fine-grained language assessment instruments such as the Preschool Language Scales (Zimmerman, Steiner, & Pond, 2011) or the MacArthur-Bates Communicative Development Inventories (Fenson et al., 2007) could have provided a more complete view of social and language development in children.

Notwithstanding such limitations, one major strength of this study is the fact that we obtained significant results despite using a conservative approach for risk analysis. Because assessing the effects of early ASD symptoms must be handled carefully while considering the social stigma for children and families, we chose to use a conservative approach through binary data even though the use of continuous outcome measures could have produced greater statistical power in the analyses to obtain significance. Furthermore, a conservative data analysis approach alleviated the fact that the sample was mostly African-American and urban-based when such characteristics could have posed challenges and biased results. Another major strength of this longitudinal study is its unique ability to examine the unique contribution of early ASD symptoms on subsequent socio-emotional-cognitive maturity in a typically developing sample while considering for other competing explanations. Future research should examine whether risk for ASD and for other neurodevelopmental psychopathologies hold long-term effects on school readiness in preschoolers.

4.2. Implications for clinical practice and research

Considering that developmental maturity in a child is a building block to future academic performance, it is critical that social, emotional, and cognitive skills are progressing on a healthy trajectory. According to the Bright Futures Steering Committee (2006), standard developmental screening tools should be used on a greater scale to identify concerns about development and children who appear to be at low risk of a developmental disorder. Also when risk concerns are identified, the child should be granted access to early developmental interventions and early childhood services. As for the CANDLE participants, we do not know how many may have received early intervention and services. Nevertheless, our study supports the finding of a negative relationship between parenting stress and both child competence and future academic functioning from a fairly recent study (Soltis, Davidson, Moreland,

Felton, & Dumas, 2015). However, our study does not exactly assess the reciprocal relationship between parent stress, early ASD symptoms, and later school readiness. As such, additional research is needed to understand that relationship. Nevertheless, clinicians may want to take parental stress into account as they intervene to enhance the development of competence and skills required in children before their entry to formal schooling. Considering that improvements in social, emotional and cognitive skills can enhance academic and behavioral functioning in kindergarten (Nix, Bierman, Domitrovich, & Gill, 2013; Welsh, Nix, Blair, Bierman, & Nelson, 2010), any behavioral intervention toward early ASD symptoms might lessen impairment to child developmental competence.

Not all children and parents from our sample require behavioral intervention even though a number of children received some type of diagnosis. Nevertheless, children and parents can rely on a number of existing programs to reduce parenting stress while children would enhance their developmental competence. Among those programs, the *Child and Family Interagency, Resource, Support, and Training* has been shown to largely reduce externalizing problems and moderately improve language skills for children aged between 6 and 36 months, while also largely reducing parenting stress (Lowell, Carter, Godoy, Paulicin, & Briggs-Gowan, 2011). First designed in the early 1970s, *Parent-Child Interaction Therapy* (PCIT) has also been shown to be a solid evidence-based parent-training intervention for children with disruptive behaviors. This treatment has been successful in improving parenting skills, and in reducing parenting stress and depression immediately and up to 6 years later (Eyberg, Boggs, & Jaccard, 2014). One of the components of PCIT is child-directed interaction, which promotes parental warmth and stronger parent-child relationship. A recent study examined the efficacy of child-directed component for children with ASD. The results show significant and meaningful improvements in child behavior and social awareness (Ginn, Clionsky, Eyberg, Warner-Metzger, & Abner, 2017). Parental distress, associated with child disruptive behavior, also significantly decreased following 8 sessions where mothers learned to provide positive attention to appropriate social and play behaviors (Ginn et al., 2017). Such interventions would add a strong building block for early child school readiness, successful transitions through school grades, and attainment of higher long-term academic achievement (Entwisle et al., 2005; Pagani et al., 2010).

Although our results show promise, we suggest future research to replicate the study with different population-based samples in other US states. This would allow better generalization of results to a greater slice of the American population. We also suggest that future research uses a different instrument, namely the *Quantitative Checklist for Autism in Toddlers* (Q−CHAT; Allison et al., 2008), to assess the risk for toddlers to potentially develop an ASD. In the Q−CHAT, ASD risk would be fully quantified based on the number and the intensity of all early symptoms. Nevertheless, we are encouraged by results that were found in the midst of a conservative approach for data analysis, and we hope that these findings will guide future research with regard to the association between early ASD symptoms in large populations of children and subsequent competence with the goal of improving school readiness.

In conclusion, our findings highlight the effects of both ASD screening scores and parenting stress on subsequent developmental maturity. ASD screening scores and parenting stress both made important contributions as predictors of socio-emotional-cognitive risk. Although few children later received an ASD diagnosis, our results suggest that the presence of early symptoms can contribute to detectable and quantitative impairment to socio-emotional-cognitive maturity. Our findings also show that parenting stress interacts with the number of early ASD symptoms, subsequently leading to more child risk outcomes. In response, the implementation of behavioral modeling to counter child ASD symptoms, coping strategies to deal with parenting stress, and inducing more positive parent-child interactions may improve child competence. In return, enhanced developmental competence would become a strong building block for early school readiness and personal success.

Conflicts of interest

There is no conflict of interest to disclose by the author.

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Appendix A. Supplementary data

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