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# Early Predictors of ASD in Young Children Using a Nationally Representative Data Set

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Current clinical diagnosis of Autism Spectrum Disorders (ASD) occurs between 3 and 4 years of age, but increasing evidence indicates that intervention begun earlier may improve outcomes. Using secondary analysis of the Early Childhood Longitudinal Study–Birth Cohort data set, the current study identifies early predictors prior to the diagnosis of ASD at 4 years for approximately 100 children. Children with ASD were compared with children with other disabilities and children who were typically developing. Multinomial logistic regression analyses identified limited unique characteristics (e.g., self-regulation and sleep patterns) at the 9-month time point. A majority of the differences in communication and language, mental/cognitive function, motor function, social interaction, and self-regulation were found at the 2-year time point. Implications for research and practice are presented.

***Keywords:*** *Autism Spectrum Disorders, ECLS-B, early predictors, multinomial logistic regression*

In 2012, the Centers for Disease Control and Prevention estimated the rate of Autism Spectrum Disorder (ASD) in approximately 1 in 88 children, affecting 1 in 54 boys and 1 in 252 girls (Centers for Disease Control and Prevention, 2012). Clinical diagnosis of ASD occurs, on average, between the ages of 3 and 4 years (Filipek et al., 1999; Goin & Myers, 2004; Zwaigenbaum et al., 2009), but there is mounting evidence that intervention beginning prior to the age of 3 may improve

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outcomes (Dawson, 2008; Robins, Fein, Barton, & Green, 2001). Recent guidelines published by the American Academy of Pediatrics recommend frequent surveillance for ASD including universal screening at 18 and 24 months with the recognition that intervention can ameliorate some of the impairments associated with ASD (Johnson, Myers, & Council on Children with Disabilities, 2007). Over the past 10 years, there has been sufficient consensus on the core deficits identifiable in children with ASD above the age of 3 to be able to agree on diagnostic criteria (Sigman, Dijamco, Gratier, & Rozga, 2004). "All children with ASD demonstrate deficits in 1) social interaction, 2) verbal and nonverbal communication, and 3) repetitive behaviors" (National Institute of Mental Health, 2004, p. 5). The same consensus has not been reached for children around the age of 2. This absence of consensus provides the impetus for this exploratory study with the purpose of identifying early predictors of ASD in infants and toddlers.

As Zwaigenbaum and colleagues (2009) indicated, there are unique challenges for applying diagnostic guidelines for ASD around the age of 2, particularly because standard criteria of the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed., text rev.; *DSM-IV-TR*; American Psychiatric Association [APA], 2000), diagnostic tools, and expert clinical judgment are rarely applied to this young age group. Yet, many parents of children with ASD have identified developmental concerns by the age of 12 to 18 months (Ozonoff et al., 2009; Robins et al., 2001) and valuable time is lost between the appearance of symptoms and diagnosis (Filipek et al., 1999; Goin & Myers, 2004). Prospective studies of infants with older siblings with ASD are the most recent approach to investigating emergence of ASD (Ozonoff et al., 2010; Wan et al., 2012; Zwaigenbaum et al., 2009). Ozonoff and colleagues (2011) reported in their study of more than 660 babies from the Baby Siblings Research Consortium that the sibling recurrence rate of ASD is significantly higher than previously estimated, supporting the need for early screening and monitoring, particularly of infants and toddlers at risk of ASD.

Filipek and colleagues (1999) found that many clinicians were hesitant to discuss the possibility of an ASD diagnosis with parents of young children even when symptoms were present. Clinicians were concerned about family distress, possible adverse effects of labeling a child, possibility of incorrect or over diagnosis, and the hope that symptoms would reverse over time. In addition, Zwaigenbaum and colleagues (2009) reported the challenges in diagnosing ASD before the age of 2 years include (a) some of the children with more intact language and intellectual development may have more subtle symptoms of ASD at an early age, (b) it may be difficult to distinguish between ASD and other atypical patterns of development (particularly communication disorders), and (c) there is some uncertainty about the stability of diagnosis in children at or near 2 years of age (for discussion, see Kleinman et al., 2008). Yet, families universally expressed desire to be informed as early as possible and the positive benefits of accurate diagnosis outweighed the negative effects (Filipek et al., 1999).

Early identification of ASD is valuable for a number of reasons. First, early identification would allow interventions to minimize or even prevent some of the symptoms and behaviors associated with ASD (Sigman et al., 2004; Stone, Coonrod, Turner, & Pozdol, 2004). Second, Dawson (2008) posits that "early intervention can alter the abnormal developmental trajectory of young children with ASD and help guide brain and behavioral development back toward a normal pathway" (p. 776). Third, early identification would allow characterization of children with ASD in early life (i.e., early toddlerhood) and broaden our understanding of the development of autism (Sigman et al., 2004). With the

need for early identification established, a review is warranted of the literature of child characteristics thought to be potential predictors of ASD in infants and toddlers.

At present, there is no biological marker or medical test to unequivocally diagnose ASD, and clinicians must rely on behavioral diagnostics (Landa & Garrett-Mayer, 2006; Zwaigenbaum et al., 2009). In addition, the triad of diagnostic characteristics associated with ASD may be more difficult to detect in children below the age of 2 or may present differently from manifestations at later ages (Nadel & Poss, 2007). Indeed, the recently published *DSM* (5th ed.; *DSM-5*; APA, 2013) emphasizes that the symptoms of impaired social communication and interaction characteristic of ASD must be present in early childhood, but may not become fully manifested until social demands exceed limited capacities. Likewise, as Leekam and colleagues (2007) reported, repetitive behaviors represent a continuum of functioning that includes typically developing 2-year-olds, in addition to young children with ASD.

Through the use of retrospective studies (e.g., parent report and home videotape analysis), behavioral differences were most evident in the second year of life, with some studies detecting signs of ASD as early as the first birthday (Osterling & Dawson, 1994; Ozonoff et al., 2010). In first birthday videotapes, Osterling and Dawson found that more than 90% of the infants with ASD could be identified by diminished eye contact, an inability to orient to name when called, as well as the absence of two joint attention behaviors, pointing with a finger to indicate interest in something and showing an object by bringing it to a person.

In a literature review of prospective studies, Zwaigenbaum and colleagues (2009) reported that by 12 to 18 months of age, infants later diagnosed with ASD exhibit impairments in at least one of the following domains: (a) visual (e.g., atypical visual tracking and fixation on objects), (b) motor (e.g., delayed fine and gross motor skills), (c) play (e.g., limited toy play and repetitive behaviors with toys), (d) social communication (e.g., atypical eye gaze and lack of orienting to name), (e) language (e.g., delayed back and forth social babbling and absence of pre-speech gesturing), and (f) general cognitive development (e.g., slower acquisition of new skills).

Investigations involving development of screening tools for early detection of autism targeting children under 3 years old have identified several distinctive behavior characteristics of infants and toddlers with ASD. Two early screening tools were reviewed, based on their availability to practitioners, their use of a parent-report component, and the brief amount of time required for administration. The *Modified Checklist for Autism in Toddlers* (MCHAT; Robins et al., 2001) identified behaviors that fail to be present in very young children with ASD including absence of (a) joint attention; (b) protodeclarative pointing; (c) bringing objects to parents; (d) interest in other children, including imitation; and (e) responding to name. In an investigation of the *Communication and Symbolic Behavior Scales Developmental Profile, Infant-Toddler Checklist* conducted by Wetherby and colleagues (2004), the team found that young children with ASD lacked appropriate gaze and joyful expressions, would not respond to their name, had difficulty coordinating gaze with facial expressions, gestures, and vocalizations, lacked intentional showing of object to someone, demonstrated unusual vocal prosody, and engaged in repetitive movements with objects. In addition, young children with ASD were likely to exhibit delays in using words and in using objects in conventional play. It should be noted that early social interaction

skills (e.g., joint attention, responding to name, showing of objects) assessed by both checklists often occur in a mother–child interactive context, given the young age of the participants. Thus, observations and assessments of the interactions between mother and child may serve to identify child behaviors or characteristics associated with ASD specific to that unique social context.

Among the characteristics less studied for young children with ASD are ear infections (Niehus & Lord, 2006; Rosenhall, Nordin, Sandström, Ahlsén, & Gillberg, 1999), sleep disorders (Cotton & Richdale, 2010; Kodak & Piazza, 2008; Kozlowski, Matson, Belva, & Rieske, 2012; Schreck & Mulick, 2000), and gastrointestinal concerns (Adams, Johansen, Powell, Quig, & Rubin, 2011; Jyonouchi, Geng, Ruby, & Zimmerman-Bier, 2005). However, in a study of 2,080 children with ASD (ages 4-18 years), Ackerman, Reilly, and Bernier (2012) reported that one in six children underwent insertion of typanostomy tubes, a majority of which were for otitis media, and one in five of the children with ASD had eight or more episodes of otitis media. Likewise, in a study by Schreck and Mulick (2000), parents of children with autism reported that their children had sleeping difficulties and impaired sleep quality significantly more often than parents of children with diagnosed cognitive disabilities and parents of children without any developmental diagnosis. In a comparison group study of 7-year-olds (range = 2.5-18 years) with and without autism, Adams and colleagues (2011) reported a strong link between severe gastrointestinal symptoms (e.g., chronic diarrhea, constipation, heartburn, bloating) and severity of symptoms of autism as rated on the Autism Treatment Evaluation Checklist subscales (Rimland & Edelson, 2000).

Notably, one of the biggest limitations of current knowledge about autism in the early years is that it is based largely on studies that use small, unrepresentative samples, with few controls for salient variables such as family demographics. For example, in a recent study, Ozonoff and colleagues (2010) described a small sample size of 25 children with ASD compared with a gender-matched group of 25 children who were typically developing. While 41% of the children with ASD were from ethnic or racial minority groups, the socioeconomic status (SES) and family composition (e.g., single parent) were not mentioned. Such methodological problems limit the ability to draw conclusion about very young children with autism and their families. Furthermore, as Luyster and colleagues (2009) suggest, there continues to be a need for diagnostic tools and interventions that are appropriate for very young children.

Studies using longitudinal data sets provide a glimpse of the functioning and outcomes for young children with autism (Bitterman, Daley, Misra, Carlson, & Markowitz, 2008; Bopp, Mirenda, & Zumbo, 2009; Scarborough et al., 2004). For example, one study examined the relationship between behaviors and language development trajectories in 69 young children (*M* age = 4.2 years old, range = 1.9-6.0 years) with ASD over a 2-year span of time (Bopp et al., 2009). They used standardized measures to assess behaviors and language at initiation of early intervention at 6 months, 12 months, and 24 months. However, the authors suggested that a larger sample group would be needed for a follow-up examination of predictive relationships. Furthermore, all of the items that were used to construct the predictor variables came solely from parent-report measures with no objective data collected by independent observers.

A handful of national, longitudinal studies have included children with autism in their sample (e.g., Pre-Elementary Education Longitudinal Study [PEELS] and National Early Intervention Longitudinal Study [NEILS]). However, these data sets do not allow for a retrospective analysis of children leading to their diagnosis. Instead, they are designed to follow a select population of children receiving special education or early intervention services (Scarborough et al., 2004). In addition, the PEELS and NEILS do not include a nationally representative comparison group of children who are typically developing, limiting the extent to which the differences found can be attributed to child developmental status.

In sum, the current research addressing health and behavioral predictors of ASD contains many methodological limitations, including the samples used, the data source, and how often and when data were collected. Our study was designed to overcome many of these methodological limitations by using the Early Childhood Longitudinal Study–Birth Cohort (ECLS-B) data set. The size and longitudinal nature of ECLS-B allow for statistically rigorous analyses. For instance, as data were collected at 9 months, 2 years, and 4 years, child characteristics and development can be assessed at multiple time points *before* parent report of diagnosis of ASD at the 4-year time point. This eliminates the biases that may be associated with retrospective studies, relying on parent memory of a previous time point or selective videotaping of activities.

The purpose of this exploratory study was to identify early predictors of ASD among infants and toddlers who were later diagnosed at the age of 4 years. Characteristics and behaviors that were evident prior to the diagnosis of ASD were examined and compared with those of children who were typically developing and with children with other disabilities, a unique comparison group in the data set. Specifically, the following research questions were addressed:

**Research Question 1:** What are the significant predictors (e.g., developmental milestones, child health characteristics) of being diagnosed with ASD at 4 years?

**Research Question 2:** Do children with and without diagnosis of ASD differ before diagnosis (i.e., at 9 months and 2 years) on behavior, language, motor skills, social skills, sleep patterns, ear infections, and mother–child interaction measures?

## Method

These research questions are based on a conceptual framework that early characteristics unique to children can be found to predict the diagnosis of ASD by the age of 4 years. Predictive factors of ASD are derived from measures of child characteristics and behaviors found in the 9-month and 2-year data collection points of the ECLS-B. Diagnosis of ASD by a physician is a dichotomous variable reported by parents at approximately 4 years of age.

Previous retrospective studies of young children with ASD have relied heavily on parent memory of a previous time or analyses of selective videotaping of a previous event or activity (e.g., birthday celebration). Unique to this study is the health and developmental characteristics captured prior to the reported diagnosis of approximately 100 children

(1% of the total sample) with ASD. In addition, comparison groups are available within the ECLS-B of approximately 1,100 children with disabilities not including ASD (12% of the total sample) and 7,700 typically developing children (87% of the total sample). As required by the National Center for Educational Statistics (NCES), sample sizes (including the sample of children with ASD) are rounded to the nearest 50.

In accordance with the existing Institutional Review Board (IRB) protocol regarding analysis of a data set already collected, this study focused on a subsample of families of children diagnosed with autism. The data packets available to researchers have been de-identified and are without any key linking identifiers to participants. In addition, employing an inferential study design on the longitudinal data found in the ECLS-B, we can infer the characteristics of all children born with ASD in 2001 from the nationally representative sample of approximately 100 children with ASD.

## Data Source

The ECLS-B is a nationally representative, longitudinal data set of approximately 11,000 U.S. children born in 2001. The data set includes oversamples of Asian and Pacific Islander children, American Indian and Alaska Native children, Chinese children, twins, and children who were low/very low birth weight, as well as maintaining representative samples of Hispanic, African American, and Caucasian children. Sample weights were applied for all analyses as directed by the NCES. Data for the ECLS-B were gathered from children, parents, child care providers, teachers, and school administrators (Snow et al., 2007). Data collection methods used in the ECLS-B included interview, survey, and observational data collection formats, and direct assessments of children's growth and development. Diverse socioeconomic and racial/ethnic backgrounds are represented in the data. Included are data from approximately 100 children diagnosed with ASD by a physician and reported by parents.

## Study Sample

Our study focused on a sample of children diagnosed with ASD. During a home interview at the third data collection point (at approximately 4 years old), parents reported whether a doctor had told them that their "child has autism or PDD" (Pervasive Developmental Disorder). It should be noted that this question was not asked at the earlier two time points of 9 months and 2 years. Growing research use of large data sets available through online registries such as the Interactive Autism Network (IAN) requires parent report of child's diagnosis of ASD to be valid and reliable. In a recent study by Daniels and colleagues (2012), parent report of diagnosis of ASD was verified by medical diagnosis documentation in 98% of the study sample participants drawn from the IAN. Likewise, the Centers for Disease Control and Prevention (2006) note the consistency in reports from the National Health Interview Survey (NHIS) and the National Survey of Children's Health (NSCH) and suggest high reliability for parental report of autism.

While significantly more children with disabilities ($p < .05$) in the ECLS-B data set were White, Hispanic, and African American in comparison with children without disabilities,

they were not statistically different than the children with ASD. Nor was the racial/ethnic composition of the sample of children with ASD statistically different than the sample of typically developing children. Likewise, comparisons of the average SES level of the three groups indicated no statistically significant differences between the groups. However, the gender variable was statistically significant ($p = .00$) in comparisons of the three groups with the group of children with ASD having a higher percentage of males than the group of children with disabilities, who in turn had a higher percentage of males than the typical group. To control for potential influences when analyzing the ECLS-B data set, the child's gender, ethnicity (e.g., White, Black, Hispanic), average age of parent or parents at child's birth, birth weight, family SES (quintile), and child's age at assessment were added as control variables to each regression model. Sample weights were applied for all analyses across all time points as directed by the NCES to allow for generalizability of study findings. The current study sample of approximately 100 children with ASD is characterized, along with their comparison groups, in Table 1.

Characteristics of the children with ASD in the ECLS-B mirror other research to date. The National Institute of Mental Health (2004) found a much higher prevalence of males (three to four times as many) diagnosed with ASD versus females. The study sample drawn from the ECLS-B is comprised of 70% males. As numerous researchers indicate, there is a strong occurrence of autism in families of Caucasian ethnicity (Hastings et al., 2005; Herring et al., 2006). In the ECLS-B sample, 45% of the children with ASD were Caucasian, yet unlike other studies, the presence of other ethnicities (e.g., Hispanic and African American) may provide future insights into unique characteristics of families of young children with ASD.

As Chawarska, Klin, and Volkmar (2008) point out, young children with ASD often have impairments in speech communication and sensory processing concerns, areas most often addressed by speech/language pathologists and occupational therapists, respectively. Analysis of the study sample of 100 children with ASD indicated that 95% of the children received speech or language therapy and 81% received occupational therapy as reported at the 4-year time point (see Table 1). In addition, a majority of the families participated in services to address the needs of their children with ASD, with 52% receiving home-based services and 68% attending early childhood special education classes.

Eleven percent of the children with ASD in the sample had epilepsy or seizures reported by their mothers at the 2-year time point. As the National Research Council (2001) notes, children with ASD are at increased risk for seizure disorders with one fourth to one third of people with ASD expected to develop seizure disorders within their lifetime. In addition, 39% of the sample children were classified as having had moderately low or very low birth weight.

In terms of family characteristics, this sample had a disproportionate distribution of families of children with ASD with higher and lower SES, with very few of the families falling into the middle quintile or middle class SES. This SES variable was created for each time point by NCES, using the following variables: maternal and paternal education, labor force status and occupation, and family income. Subjects received a score of 1 to 5 indicating which quintile they belonged, with 5 being the highest. In addition, a majority (68%) of the families of children with ASD were comprised of a biological mother and father, whereas 30% were headed by a single biological mother.

**Table 1**
**Demographics of Children at Wave 3 (~4 Years Old)**

| Variable | ASD % ($n$ = ~100) | Disability % ($n$ = ~1,100) | Typical development % ($n$ = ~7,700) |
|---|---|---|---|
| Gender | | | |
| Male | 70 | 61 | 49 |
| Female | 30 | 39 | 51 |
| Race/ethnicity | | | |
| White | 45 | 51 | 43 |
| Black/African American | 13 | 17 | 15 |
| Hispanic race identified | 16 | 12 | 14 |
| Hispanic race not identified | 7 | 5 | 6 |
| Asian | 10 | 4 | 11 |
| Native Hawaiian/Native American | 0 | 3 | 3 |
| More than one race, non-Hispanic | 8 | 7 | 8 |
| Not reported | 1 | <1 | <1 |
| Services received | | | |
| Speech or language therapy | 95 | 39 | <.2 |
| Occupational therapy | 81 | 25 | <.1 |
| Physical therapy | 36 | 22 | <.1 |
| Vision services | 15 | 14 | <.1 |
| Hearing services | 18 | 9 | <.1 |
| Psychological services | 31 | 10 | <.1 |
| Home services | 52 | 22 | <.1 |
| Parent support or training | 37 | 12 | <.1 |
| Special classes with children with disabilities | 68 | 22 | <.1 |
| Private tutoring or school for learning problems | 27 | 8 | <.1 |
| Caregivers | | | |
| Biological mother and father | 68 | 63 | 72 |
| Biological mother and other father figure | 2 | 9 | 5 |
| Biological mother and no father figure | 30 | 24 | 20 |
| Other | 0 | 5 | 3 |
| Socioeconomic status | | | |
| First quintile (lowest SES) | 24 | 18 | 18 |
| Second quintile | 10 | 24 | 18 |
| Third quintile | 10 | 21 | 20 |
| Fourth quintile | 26 | 19 | 20 |
| Fifth quintile (highest SES) | 31 | 18 | 24 |

*Note.* ASD = Autism Spectrum Disorder; SES = socioeconomic status.

## Measures

The ECLS-B provides comprehensive information at multiple time points, which allowed for the construction of a wide range of variables for analyses. Information was drawn from demographics (e.g., family income, marital status, race/ethnicity, and SES),

child characteristics (e.g., age, gender, birth weight, age at assessment, health history, nutritional practices, developmental milestones, language development, and socioemotional development). These constructed variables consisted of the skills of communication, cognition, motor, social interaction, and self-regulation, as well as health characteristics. Psychometric properties of the assessment instruments are described in the Appendix, and complete ECLS-B psychometric reports describing the design, development, and psychometric properties of the child assessment instruments, interviewer observations of the child, and the indirect child assessments through parent interviews are available on the NCES website (http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2007084).

Characteristics of children were compared at the first two time points of data collection (9-month and 2-year time points), with the means and standard deviations of all characteristics and behaviors calculated. To identify characteristics unique to ASD, we used multinomial logistic regression (MLR) analysis, in which the children with ASD were compared with the large sample of children who were typically developing, as well as to the children with disabilities not including ASD.

## Data Analysis

The ECLS-B data set employs a complex survey design with a multistage cluster sample (Snow et al., 2007), in which the selection of one participant is related to the selection of another subject, and therefore is not a random selection. In addition, certain subgroups were oversampled and standard errors may be underestimated. Therefore, we followed guidelines outlined by the NCES for adjusting standard errors through jackknifing procedures and application of appropriate weights, so that findings can be generalized to the U.S. population of children born in 2001. The statistical software *Stata 11* (StataCorp, 2009) was used to compute basic descriptive statistics and more complex statistical models (i.e., MLR). To account for the complex sampling design and to produce unbiased standard errors, probability sample weights were used and standard errors were estimated using the jackknife (JK2) replication method using 90 replicate weights in *Stata 11*. These necessary sample and replicate weights are available with the ECLS-B data set. To specify the sampling weight, replicate weights, and variance component in *Stata 11*, the following command was used: "svyset [pweight=*weight*], jkrw(*replicate_weight_1 - replicate_weight_90*) vce(jackknife)." Additional commands used to generate estimates were "*svy: mlogit*" and "*svy: mean*" with "*estat sd.*" Four sets of weights (and their accompanying replicate weights) were used in our analyses to obtain estimates that are nationally representative and to obtain unbiased estimates of the standard errors of these estimates. For analyses with 9-month parent-reported predictors, the *W31R0* weight was used. For analyses with 2-year parent-reported predictors, the *W3R0* weight was used. For analyses with 9-month direct assessment predictors, the *W31C0* weight was used. For analyses with 2-year direct assessment predictors, the *W3C0* weight was used.

It should be noted that the ECLS-B includes a wide age range at assessment for all the children at the 9-month, 2-year, and 4-year time points. While standardized measures account for age at assessment, parent report and observer rating of child behavior may be affected by a 15-month range at the first time point at which children were between 6.9 and

22.2 months ($M$ = 9.7) and a 21-month range at the second time point at which children were between 16.9 and 38.2 months ($M$ = 24.4). In addition, there was a 21-month range at the third time point at which children were between 44 and 65 months ($M$ = 52.5). Therefore, it was critical to include appropriate weights and controls for the assessment age in our analyses to minimize the effect of the wide age ranges. Notably, the ages of the children with ASD (range = 8.4-16.3 months at the 9-month time point and 22.9-28.9 months at the 2-year time point) were very close in age to the stated mean, with a minimal variation.

To address the research questions, the following analyses were conducted: (a) estimation of descriptive statistics and (b) MLR. Descriptive statistics were calculated on all measures to determine the characteristics of the samples of the children diagnosed with ASD, children with disabilities, and typically developing children. Demographic characteristics may differ between the group of children with ASD and the two comparison groups, and these differences may confound the relationship between early predictors and later diagnosis. Thus, we controlled for potential influences of the child's gender, ethnicity, average age of parent or parents at child's birth, birth weight, family SES (quintile), and child's age at assessment when conducting MLR analyses.

For nearly all variables, missing data were limited to less than 2%. However, the inclusion of the previously noted demographic variables in each regression model helped reduce the risk for bias due to missing data. For the small number of variables in the social interaction analysis with significant missing data (~16%), analyses revealed that children with ASD were no more likely to have missing data than the other two groups. Thus, it is less likely that the missing data for these variables or any other variables biased our results. Because of missing data, sample sizes vary slightly from one analysis to another. Finally, the use of the weights and five possible "missing data codes" provided by NCES reduced any bias associated with missing data, including bias due to attrition.

In this study, we examined the characteristics of children diagnosed with ASD to address the first research question, "What are the significant predictors (e.g., developmental milestones, child health characteristics) of being diagnosed with ASD at 4 years?" Based on the developmental characteristics identified by the literature on young children with ASD, a list of variables was generated. Means and standard deviations for each variable were calculated. To address the second research question, "Do children with and without diagnosis of ASD differ before diagnosis (i.e., at 9 months and 2 years) on behavior, language, motor skills, social skills, sleep patterns, ear infections, and mother–child interaction measures?," we analyzed whether children with and without diagnosis of ASD differed before diagnosis (i.e., at 9 months and 2 years) on behavior, language, social skills, sleep patterns, and mother–child interaction measures. The question included a comparison of children with ASD to both the larger sample of all children with typical development (approximately 7,700 children) and a sample of children with disabilities not including ASD (approximately 1,100 children). As listed in the ECLS-B parent questionnaire, the sample of children with other disabilities consisted of children with: (a) blindness, (b) hearing impairment or deafness, (c) speech and language impairments, (d) "mental retardation," (e) orthopedic impairments, (f) other health impairments (e.g., spina bifida, Turner's syndrome), and (g) developmental delays, as well as those receiving Part C early intervention services or early childhood special education services.

MLR was used to predict group membership (children diagnosed with ASD, children with other disabilities, or typically developing children) using the previously identified variables as potential predictors. Specifically, we used MLR to determine whether a skill such as communication significantly predicted membership in the group of children with ASD rather than the group of children with other disabilities. If communication skills significantly predicted membership in the group of children with ASD, then it would be a potential early predictor of a later diagnosis of ASD. These MLR analyses are typically interpreted in terms of odds ratios (the odds of being diagnosed with ASD divided by the odds of being in a comparison group of typically developing children or children with other disabilities). For our analyses, an odds ratio greater than 1 indicates that receiving a higher score on a predictor is associated with an increased likelihood of later diagnosis of ASD. We standardized all predictor variables to make comparisons across analyses and to observe the relative strength of the predictors. Thus, the odds ratios reported in Tables 3 through 5 represent how much the odds of being diagnosed with ASD increased or decreased when the predictor variable increased by 1 standard deviation.

# Results

## Predictors of Diagnosis of ASD

To explore the early identifying characteristics prior to diagnosis of ASD, documented at the third time point (4 years), characteristics of children were compared at the first two time points of data collection (9-month and 2-year time points). The means and standard deviations of all characteristics and behaviors are reported in Table 2. These variables were further examined using MLR analysis, in which the children with ASD were compared with the large sample of children who were typically developing as well as with the children with disabilities, not including ASD, in an effort to identify characteristics unique to ASD. These findings are reported in Tables 3 to 5.

*Communication.* As depicted in Table 3, in the domain of communication, there were no differences found between the children with ASD and the children with disabilities or the children who were typically developing at the 9-month time point. It is important to note that at this first time point, babbling, as measured on the *Bayley Short Form–Research Edition* (*BSF-R*; Bayley, 1993), was the only measure of communication reported.

At the 2-year time point, communication skills consisted of parent report of the number of words spoken and the *BSF-R* proficiency probabilities for different communication skills created by NCES, including jabbering, naming object, expressive vocabulary, receptive vocabulary, and listening comprehension. The *BSF-R* items were averaged to form a composite proficiency score with a possible range of 0 to 100. Children with ASD scored significantly lower on both measures of communication compared with children with disabilities and typically developing children.

*Mental/cognitive and motor.* On the *BSF-R* Mental/Cognitive Scale Scores and the Motor Scale Scores (fine and gross motor composite), the children with ASD showed no significant

**Table 2**
**Population Estimates of Means and Standard Deviations of Predictor Variables for Children With ASD, Children With Disabilities, and Typically Developing Children at Two Time Points While Controlling for Demographics**

| | First time point (9 months old) | | | | | | Second time point (24 months old) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ASD/autism | | Disabilities | | Typical development | | ASD/autism | | Disabilities | | Typical development | |
| Predictor variable | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| Communication skills | | | | | | | | | | | | |
| Babbles (*BSF-R*) | 31.56 | 25.30 | 37.18 | 30.70 | 41.66 | 26.97 | | | | | | |
| Communication proficiency | | | | | | | 47.43 | 20.13 | 69.00 | 19.09 | 77.95 | 13.25 |
| Number of words | | | | | | | 9.59 | 11.43 | 21.63 | 14.49 | 29.87 | 11.20 |
| Mental Index Score (*BSF-R*) | 73.40 | 8.32 | 75.07 | 11.55 | 76.81 | 9.45 | 108.86 | 13.18 | 121.62 | 12.30 | 127.85 | 10.07 |
| Motor Index Score (*BSF-R*) | 54.81 | 11.04 | 54.07 | 11.66 | 56.14 | 8.96 | 74.69 | 5.78 | 79.65 | 6.72 | 81.74 | 4.78 |
| Social interaction | | | | | | | | | | | | |
| *NCATS* (total score for child) | 14.57 | 3.19 | 15.34 | 3.01 | 15.54 | 2.66 | | | | | | |
| Observation of social behavior composite (*BRS*) | −0.39 | 1.02 | −0.02 | 0.80 | 0.00 | 0.68 | −1.10 | 0.76 | −0.24 | 0.87 | 0.03 | 0.73 |
| Two Bags Task | | | | | | | | | | | | |
| Engage parent | | | | | | | 3.48 | 1.22 | 4.28 | 1.18 | 4.59 | 1.12 |
| Negativity toward parent | | | | | | | 1.54 | 0.88 | 1.45 | 0.89 | 1.35 | 0.74 |
| Sustained attention | | | | | | | 3.23 | 0.78 | 4.22 | 1.23 | 4.50 | 1.12 |
| Self-regulation composite (*ITSC*) | 0.06 | 0.62 | 0.02 | 0.68 | 0.00 | 0.57 | 0.35 | 0.68 | 0.11 | 0.71 | −0.02 | 0.57 |
| Self-regulation (hotspots) | | | | | | | | | | | | |
| Demandingness | | | | | | | 3.01 | 3.95 | 0.30 | 3.90 | −0.06 | 3.39 |
| Warmth | | | | | | | −1.01 | 1.43 | −0.17 | 1.16 | 0.03 | 0.97 |
| Avoidance | | | | | | | 0.79 | 1.15 | 0.12 | 1.15 | −0.02 | 0.98 |

*(continued)*

**Table 2 (continued)**

| | First time point (9 months old) | | | | | | Second time point (24 months old) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ASD/autism | | Disabilities | | Typical development | | ASD/autism | | Disabilities | | Typical development | |
| Predictor variable | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| Sleep patterns (*ITSC*) | | | | | | | | | | | | |
| Wakes up 3 or more times | 0.90 | 1.08 | 0.53 | 0.98 | 0.47 | 0.80 | | | | | | |
| Needs help to fall asleep | 1.19 | 1.34 | 0.93 | 1.29 | 0.92 | 1.12 | 1.15 | 1.35 | 0.85 | 1.27 | 0.88 | 1.12 |
| Overall health (parent interview) | 3.84 | 1.26 | 3.80 | 1.10 | 3.97 | 0.94 | 3.98 | 1.16 | 4.21 | 1.01 | 4.50 | 0.73 |
| Gastrointestinal concerns | 0.17 | 0.43 | 0.09 | 0.32 | 0.05 | 0.22 | 0.11 | 0.35 | 0.05 | 0.25 | 0.03 | 0.18 |
| Lactose intolerance | | | | | | | 0.04 | 0.22 | 0.09 | 0.31 | 0.04 | 0.19 |
| Food allergies | | | | | | | 0.07 | 0.29 | 0.06 | 0.27 | 0.04 | 0.20 |
| Ear infections | 1.17 | 1.83 | 1.31 | 2.79 | 0.91 | 1.67 | 3.21 | 4.69 | 1.87 | 3.85 | 1.14 | 2.05 |
| Epilepsy | | | | | | | 0.03 | 0.19 | 0.17 | 0.42 | 0.00 | 0.00 |
| Difficulty to raise | 2.11 | 1.17 | 2.03 | 1.23 | 1.90 | 0.97 | 2.81 | 1.39 | 2.43 | 1.23 | 2.18 | 1.03 |

*Note.* Demographic control variables: child gender, race/ethnicity, average age of biological parents, low birth-weight status, and by time point, SES quintile and child assessment age. ASD = Autism Spectrum Disorder; *BSF-R = Bayley Short Form–Research Edition*, a short form of the *Bayley Scales of Infant Development, Second Edition* (*BSID-II*; Bayley, 1993); *NCATS = Nursing Child Assessment Teaching Scale* (Sumner & Spietz, 1994); *BRS = Behavior Rating Scale* of *Bayley Scales of Infant Development, Second Edition* (*BSID-II*; Bayley, 1993); Parent Interview questions for Self-Regulation and Sleep Patterns from *Infant/Toddler Symptom Checklist* (*ITSC*; DeGangi, Poisson, Sickel, & Wiener, 1995); SES = socioeconomic status.

**Table 3**
**Comparison of Communication, Cognitive, and Motor Skills of Children With ASD to Children With Disabilities and Typically Developing Children at Two Time Points While Controlling for Demographics**

| | 9 months old (standardized estimates) | | | | | 24 months old (standardized estimates) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Predictor variables for communication, cognitive, and motor skills | β | *SE* | *p* | Odds ratio[a] | 95% CI | β | *SE* | *p* | Odds ratio[a] | 95% CI |
| Children with disabilities, no ASD | | | | | | | | | | |
| Babbles (*BSF-R*) | −.28 | 0.38 | .470 | 0.76 | [0.35, 1.62] | — | — | — | — | — |
| Communication proficiency | — | — | — | — | — | −.95 | 0.20 | .000 | 0.39 | [0.26, 0.57] |
| Number of words | — | — | — | — | — | −1.43 | 0.36 | .000 | 0.24 | [0.12, 0.48] |
| Mental Index Score (*BSF-R*) | −.14 | 0.33 | .675 | 0.87 | [0.45, 1.68] | −1.19 | 0.27 | .000 | 0.30 | [0.18, 0.52] |
| Motor Index Score (*BSF-R*) | .42 | 0.31 | .179 | 1.52 | [0.82, 2.83] | −.76 | 0.16 | .000 | 0.47 | [0.34, 0.65] |
| Typically developing children | | | | | | | | | | |
| Babbles (*BSF-R*) | −.71 | 0.38 | .067 | 0.49 | [0.23, 1.05] | — | — | — | — | — |
| Communication proficiency | — | — | — | — | — | −1.56 | 0.20 | .000 | 0.21 | [0.14, 0.31] |
| Number of words | — | — | — | — | — | −2.15 | 0.35 | .000 | 0.12 | [0.06, 0.23] |
| Mental Index Score (*BSF-R*) | −.63 | 0.33 | .057 | 0.53 | [0.28, 1.02] | −1.86 | 0.27 | .000 | 0.16 | [0.09, 0.27] |
| Motor Index Score (*BSF-R*) | −.01 | 0.30 | .982 | 0.99 | [0.54, 1.82] | −1.13 | 0.15 | .000 | 0.32 | [0.24, 0.44] |

*Note.* Demographic control variables: child gender, race/ethnicity, average age of biological parents, low birth-weight status, and by time point, SES quintile and child assessment age. ASD = Autism Spectrum Disorder; *BSF-R* = *Bayley Short Form–Research Edition*, a short form of the *Bayley Scales of Infant Development, Second Edition* (*BSID-II*; Bayley, 1993); SES = socioeconomic status.

[a]The odds ratio indicates how much the odds of being diagnosed with ASD (versus the comparison group) increases (or decreases) as the predictor variable increases by 1 *SD*.

**Table 4**
**Comparison of the Social Interaction Skills of Children With ASD to Children With Disabilities and Typically Developing Children at Two Time Points While Controlling for Demographics**

| | 9 months old (standardized estimates) | | | | | 24 months old (standardized estimates) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Predictor variables for social interaction | β | *SE* | *p* | Odds ratio[a] | 95% CI | β | *SE* | *p* | Odds ratio[a] | 95% CI |
| Children with disabilities, no ASD | | | | | | | | | | |
| Social interaction | | | | | | | | | | |
| *NCATS* (total score for child) | −.29 | 0.23 | .224 | 0.75 | [0.47, 1.19] | — | — | — | — | — |
| Observation of social behavior composite (*BRS*) | −.48 | 0.27 | .075 | 0.62 | [0.37, 1.05] | −1.07 | 0.16 | .000 | 0.34 | [0.25, 0.48] |
| Engage parent (Two Bags Task) | — | — | — | — | — | −.72 | 0.21 | .001 | 0.49 | [0.32, 0.74] |
| Negativity to parent (Two Bags task) | — | — | — | — | — | .07 | 0.12 | .564 | 1.07 | [0.84, 1.38] |
| Sustained attention (Two Bags Task) | — | — | — | — | — | −.87 | 0.12 | .000 | 0.42 | [0.33, 0.53] |
| Typically developing children | | | | | | | | | | |
| Social interaction | | | | | | | | | | |
| *NCATS* (total score for child) | −.34 | 0.23 | .135 | 0.71 | [0.45, 1.11] | | | | | |
| Observation of social behavior composite (*BRS*) | −.50 | 0.27 | .062 | 0.61 | [0.36, 1.03] | −1.38 | 0.17 | .000 | 0.25 | [0.18, 0.35] |
| Engage parent (Two Bags Task) | — | — | — | — | — | −.98 | 0.21 | .000 | 0.38 | [0.25, 0.57] |
| Negativity to parent (Two Bags Task) | — | — | — | — | — | .17 | 0.11 | .134 | 1.18 | [0.95, 1.47] |
| Sustained attention (Two Bags Task) | — | — | — | — | — | −1.09 | 0.13 | .000 | 0.34 | [0.26, 0.43] |

*Note.* Demographic control variables: child gender, race/ethnicity, average age of biological parents, low birth-weight status, and by time point, SES quintile and child assessment age. ASD = Autism Spectrum Disorder; *NCATS* = *Nursing Assessment Teaching Scale* (Sumner & Spietz, 1994); *BRS* = *Behavior Rating Scale* of *Bayley Scales of Infant Development, Second Edition* (Bayley, 1993); SES = socioeconomic status.

[a]The odds ratio indicates how much the odds of being diagnosed with ASD (versus the comparison group) increases (or decreases) as the predictor variable increases by 1 *SD*.

**Table 5**
**Comparison of the Self-Regulation Skills of Children With ASD to Children With Disabilities and Typically Developing Children at Two Time Points While Controlling for Demographics**

| | 9 months old (standardized estimates) | | | | | 24 months old (standardized estimates) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Predictor variables for self-regulation | β | *SE* | *p* | Odds ratio[a] | 95% CI | β | *SE* | *p* | Odds ratio[a] | 95% CI |
| Children with disabilities, no ASD | | | | | | | | | | |
| Self-regulation (hotspots) | | | | | | | | | | |
| Demandingness | — | — | — | — | — | .62 | 0.15 | .000 | 1.85 | [1.37, 2.51] |
| Warmth | — | — | — | — | — | −.70 | 0.18 | .000 | 0.49 | [0.34, 0.71] |
| Avoidance | — | — | — | — | — | .54 | 0.18 | .003 | 1.72 | [1.21, 2.46] |
| Self-regulation composite (*ITSC*) | .13 | 0.17 | .458 | 1.13 | [0.81, 1.59] | .47 | 0.15 | .002 | 1.60 | [1.19, 2.14] |
| Sleep patterns (*ITSC*) | | | | | | | | | | |
| Wakes up 3 or more times | .28 | 0.13 | .030 | 1.32 | [1.03, 1.69] | — | — | — | — | — |
| Needs help to fall asleep | .18 | 0.15 | .225 | 1.20 | [0.89, 1.61] | .22 | 0.18 | .224 | 1.24 | [0.87, 1.76] |
| Typically developing children | | | | | | | | | | |
| Self-regulation (hotspots) | | | | | | | | | | |
| Demandingness | — | — | — | — | — | .70 | 0.15 | .000 | 2.01 | [1.49, 2.70] |
| Warmth | — | — | — | — | — | −.92 | 0.18 | .000 | 0.40 | [0.28, 0.55] |
| Avoidance | — | — | — | — | — | .67 | 0.18 | .000 | 1.95 | [1.38, 2.78] |
| Self-Regulation Composite (*ITSC*) | .14 | 0.16 | .373 | 1.15 | [0.84, 1.58] | .66 | 0.15 | .000 | 1.94 | [1.44, 0.63] |
| Sleep patterns (*ITSC*) | | | | | | | | | | |
| Wakes up three or more times | .35 | 0.12 | .006 | 1.42 | [1.11, 1.82] | — | — | — | — | — |
| Needs help to fall asleep | .19 | 0.15 | .208 | 1.21 | [0.90, 1.64] | .19 | 0.18 | .295 | 1.21 | [0.85, 1.72] |

*Note.* Demographic control variables: child gender, race/ethnicity, average age of biological parents, low birth-weight status, and by time point, SES quintile and child assessment age. Parent Interview questions for self-regulation and sleep patterns from *Infant/Toddler Symptom Checklist* (*ITSC*; DeGangi, Poisson, Sickel, & Wiener, 1995); ASD = Autism Spectrum Disorder; SES = socioeconomic status.

[a]The odds ratio indicates how much the odds of being diagnosed with ASD (versus the comparison group) increases (or decreases) as the predictor variable increases by 1 *SD*.

difference from the other two groups at 9 months of age. However, at 2 years of age, the children with ASD had significantly lower scores on both Mental/Cognitive Scale Scores and Motor Scale Scores than children who were typically developing.

*Social interaction.* Coded videotaped observations of mother and child interactions using the *Nursing Child Assessment Teaching Scale* (*NCATS*; Sumner & Spietz, 1994) were collected only at the 9-month time point on approximately 4,900 children, with 57% of the children with ASD having this information. Total Child interaction scores on the *NCATS* were used as measures of social interaction. As noted in Table 4, children with ASD scored lower on the *NCATS* when compared with both children with disabilities and those who were typically developing, but none of these differences were statistically significant.

In addition, home visit observations of each child recorded by an independent interviewer on the *Behavior Rating Scale* (*BRS*) taken from the full *Bayley Scales of Infant Development–Second Edition* (Bayley, 1993) were examined. There were strong correlations among the ratings of the 10 behaviors observed at both the 9-month and 2-year time points (Cronbach's $\alpha = .78$ at 9 months; Cronbach's $\alpha = .91$ at 2 years). At the 9-month time point, these behaviors consisted of (a) displays engaging behavior, (b) positive affect, (c) negative affect, (d) adapts to change in material, (e) shows interest in material, and (f) pays attention to task. In addition, the 2-year time point also consisted of (a) persistence in task, (b) displays fearfulness, (c) displays frustration in tasks, and (d) displays cooperation. These variables were standardized and averaged at each time point to create a composite score.

When comparing the children at the 2-year time point, children with ASD scored significantly lower on the *BRS* composite compared with both the children with disabilities and the children who were typically developing, as reported in Table 4. At 2 years of age, when compared with both peer groups, children with ASD demonstrated less engaging behavior, less positive affect, more intense displays of negative affect, less ability to relinquish materials or accept new materials, less attention to task, less persistence in task, more fearful behavior, more frustration in tasks, and less cooperative behavior or resistance to suggestions.

At the 2-year time point, the Two Bags Task was used in place of the NCATS with parent and child asked to play for 10 min with two different sets of toys: a small set of dishes for pretend play and the children's book "Good Night, Gorilla" (Rathmann, 1994) for joint book reading. While viewing videotapes of the Two Bags Task, independent coders recorded parent and child behaviors during interactions. The ECLS-B data set reported on this variable for 88% of the typically developing children, 86% of the children with disabilities, and 74% of the children with ASD. As illustrated in Table 4, children with ASD were less likely to engage their parents and had less sustained attention to objects than children with disabilities and those who were typically developing.

*Self-regulation.* In measures of the domain of attachment, including social and self-regulation behaviors, the ECLS-B employed the *Toddler Attachment Sort–45* (*TAS-45*), which is a modified version of the *Attachment Q-Sort* (*AQS*; Waters & Deane, 1985). At the 2-year time point, 45 items representing nine areas labeled "Hotspots" were sorted (highest to lowest occurring behavior) by an independent interviewer at the end of a 2-hr

or more home visit. Factor analysis of the nine areas indicated the presence of three factors: Demandingness (Cronbach's α = .89), Warmth (Cronbach's α = .83), and Avoidance (a single variable). Examining the three composite scores derived from the factor analysis of the nine areas indicated that children with ASD had more negative social and self-regulatory behaviors than children with disabilities or who were typically developing, as seen in Table 5.

Specifically, children with ASD were less warm and cuddly, less likely to enjoy the company of others, more demanding of parent attention, more upset by separation from parent, more likely to prefer interacting with objects versus other people, more demanding of their own way and quick to cry, and had more unusual behaviors (e.g., quick mood changes, looked dazed or confused) than children with disabilities or who were typically developing.

The domain of self-regulation was studied further in the parent interview (computer-assisted personal interview, CAPI) with questions taken from the *Infant/Toddler Symptoms Checklist* (ITSC; DeGangi, Poisson, Sickel, & Wiener, 1995). A composite variable was created by standardizing and averaging scores on the 10 self-regulation questions, which consisted of (a) fussy or irritable, (b) goes from whimper to intense cry, (c) demands attention or company, (d) startled by loud noises, (e) cries for food or toys, (f) unable to wait without crying, (g) easily distractible, (h) tunes out from activity, (i) cannot shift focus easily, and (j) time spent calming. This self-regulation variable, as reported in Table 5, was analyzed at the first time point (Cronbach's α = .53) and the second time point (Cronbach's α = .68). Children with ASD did not differ from their peers on self-regulation skills at 9 months of age but were significantly different at 2 years of age. An in-depth look at the individual variables revealed that 2-year-olds with ASD were more likely than peers to tune out from an activity and were difficult to re-engage, were unable to shift focus easily, and required more time to calm from an upsetting event. At both 9 months and 2 years of age, children with ASD were more often reported to go from whimpering to intense crying than typically developing children but not significantly more than children with disabilities.

Furthermore, sleep patterns were analyzed based on parent responses to the *ITSC*. Children with ASD were not more likely to need help falling asleep at either 9-month or 2-year time points than their peers with disabilities or who were typically developing. However, children with ASD were more likely to wake up three or more times per night at the 9-month point (the only time point when this question appeared) when compared with children with disabilities and with children who were typically developing.

*Health.* Using parent interview responses about overall child health, analyses indicated that the health of the children with ASD was not significantly different than the health of children with disabilities or who were typically developing at the 9-month or 2-year time points. Likewise, when analyzing nutritional concerns (e.g., gastrointestinal concerns, lactose intolerance, and food allergies), parents of children with ASD did not report significantly more gastrointestinal difficulties than parents of the comparison groups.

Parents of all children were asked whether their child had ear infections in previous months and to indicate the number of these infections. We created a composite variable of these two variables and found that the number of ear infections was significantly higher for

children with ASD at the 2-year time point when compared with children with disabilities (β = .17, *SE* = 0.07, $p < .022$, odds ratio = 1.18, 95% confidence interval [CI] = [1.03, 1.36]) and children who were typically developing (β = .38, *SE* = 0.08, $p < .000$, odds ratio = 1.46, 95% CI = [1.24, 1.72]).

At the 2-year time point, parents were asked whether a doctor had ever told them that their child had epilepsy or seizures. By definition, no children with a diagnosis of epilepsy were included in the group of children who were typically developing. Thus, logistic regression was used to compare whether children diagnosed with ASD were more likely to be diagnosed with epilepsy or seizures than children with disabilities. Epilepsy or seizures were not found to occur more often in children with ASD (*M* = 0.03, *SD* = 0.19) than in children with disabilities (*M* = 0.17, *SD* = 0.42). Also during the parent interview, at the 9-month and 2-year time points, parents were asked to rate the overall degree of difficulty their child would present for the average parent to raise. Only at the 2-year time point, parents of children with ASD rated their child as significantly more difficult to raise than parents of children with disabilities (β = .35, *SE* = 0.17, $p < .048$, odds ratio = 1.42, 95% CI = [1.00, 2.01]) and children who were typically developing (β = .56, *SE* = 0.17, $p < .002$, odds ratio = 1.18, 95% CI = [1.24, 1.72]).

### Unique Differences Prior to Diagnosis of ASD

In response to the second research question, children with ASD displayed differences in characteristics and behaviors when compared with children with disabilities and with children who were typically developing. Only a small number of characteristics, self-regulatory and sleep patterns, were identified as different for children with ASD at the 9-month time point. A majority of the differences appeared across multiple domains at the 2-year time point for children later diagnosed with ASD. Significant differences were found in communication and language, mental/cognitive function, motor function, social interaction, and self-regulation. Furthermore, at 2 years of age, children with ASD were rated by their parents to be similar in overall health to both comparison groups, but children with ASD were reported to have more ear infections than children with disabilities or who were typically developing. Two-year-old children with ASD had a significant occurrence of epilepsy or seizures and were rated by their parents as more difficult to raise than both peer groups. While controlling for several demographic characteristics, we found significant predictors that successfully differentiated children later diagnosed with ASD from both peer groups.

## Discussion

The current study was designed to overcome many of the methodological limitations of previous research addressing predictors of ASD. The ECLS-B data set, with its retrospective look at information provided before the diagnosis of ASD, provides a unique insight into the characteristics present at 9 months and 2 years of age. The ECLS-B eliminates the biases associated with retrospective studies, which usefully laid the groundwork on the

presence of characteristics in the toddler years, but relied on parent memory of a previous time point or selective videotaping of activities (Baranek, 1999; Osterling & Dawson, 1994; Ozonoff et al., 2010). In addition, a major strength of our study is that it captures characteristics of the same group of children with ASD across multiple time points and developmental domains.

While the literature suggests that there are manifestations of ASD between 12 months and 3 years (Webb & Jones, 2009; Zwaigenbaum et al., 2005), we found a very limited number of characteristics at the age of 9 months. Self-regulatory behaviors (e.g., demanding attention or constant company) and excessive wakefulness at night (i.e., waking more than three times per night), while present at 9 months for children with ASD, were not significantly different from those same characteristics in children with other disabilities. In other words, those features were not unique predictors of ASD.

The large number of differences noted in our study occurred at the 2-year time point and confirmed previous research findings. Significant differences were found in communication skills and word counts in our study, mirroring findings by Wetherby and colleagues (2004) and in a synthesis of studies as reported by Chawarska and colleagues (2008). Our study contributes to our understanding of communication impairments by demonstrating similar findings in a relatively large sample of children with ASD. In addition, our study confirmed that parents were indeed identifying serious communication concerns and seeking speech and language services.

Our study also identified difficulties in mental and cognitive function and the notable occurrence of epilepsy in 2-year-olds with ASD, confirming findings by Gabis, Pomeroy, and Andriola (2005), in their study of encephalograms of children with autism. Our findings add strength to the finding of epilepsy or seizures in children with ASD and indicate that future research should analyze the interaction between cognitive function and seizures. It is important to identify concomitant impairments to assist in guiding intervention strategies (educational and medical).

While there was not a consensus in the literature regarding motor impairment in children with ASD, our study found differences in motor skills as measured on the *BSF-R* (Bayley, 1993). The *BSF-R* Motor Scale Scores indicate children's fine motor skills such as grasping and manipulating small objects, as well as gross motor skills such as sitting, standing, and walking. Zwaigenbaum and colleagues (2009) noted both fine and gross motor impairments similar to the findings of our study. Comparing children in a nationally representative sample provides compelling data that suggest that children with ASD are at risk of motor impairments.

While 2-year-old children with ASD were rated by their parents as in somewhat poorer health than their peers with and without disabilities, the difference was not statistically significant. Yet the health characteristics of children with ASD should be explored further, particularly with the nutritional interventions (e.g., gluten-free, casein-free diets) that are currently advertised in the public media as potential curative interventions for the disability (Adams, 2013).

Similar to studies by Niehus and Lord (2006) and Rutter (2006), we found significantly more ear infections among 2-year-old children with ASD when compared with both peer groups. With the possible link between language acquisition impairment (a core concern in ASD) and ear infection (Winskel, 2006), more research is needed. Considering the

impairments in communication, self-regulation, and social skills found in our study, it is not surprising that parents would rate their 2-year-olds with ASD as more difficult to raise than their peers.

## Limitations

Although a range of measures on a variety of domains were used in gathering information for the ECLS-B, the range of information in each of the domain categories was relatively narrow at times. For example, absence of age-appropriate communication skills has been cited in the literature (Ozonoff et al., 2010; Wetherby et al., 2004) and was found in the scores from the *BSF-R* (Bayley, 1993) at the 2-year time point in the current study, but "babbling" presence or absence at the 9-month time point does not address the variety of ways that infants communicate and areas in which children with ASD may be exhibiting impairment (e.g., social smiling, communicative pointing at objects, reaching toward others, and response to name). Likewise, useful information about how the children socially interacted with their parents was reported, but a measure of interest addressing interaction with other children was absent.

While parent report is an acceptable method for documenting diagnosis of ASD (Centers for Disease Control and Prevention, 2006; Daniels et al., 2012), the absence of an actual age of diagnosis is a potential concern. The corroboration of a medical history document would strengthen our understanding of the term/terms used in an initial diagnosis given in the toddler and preschool years. Without the actual age of diagnosis, it is difficult to know when families first sought medical help and intervention for characteristics and behaviors specifically associated with ASD between the ages of 2 and 4 years.

The range of disabilities found in the heterogeneous sample of "other disabilities" used in our analyses could have had an impact on the comparisons made between children with ASD and children with other disabilities. The wide variation in the skills and functional abilities on assessment measures of children reported to have a disability could explain the differences (or lack of differences) between these two disability groups. An area for future research with the ECLS-B data set would be to identify specific disabilities for comparison groupings or comparisons made on groupings based on functional skills and abilities of the children.

With the sample size of approximately 100 children with ASD, it is worthwhile to note that complex statistical analyses may have been limited in the power to detect significant findings, particularly at the 9-month time point. Increasing sample size is often the easiest way to improve the statistical power of an analysis. Future comparison studies using large data sets available through online registries such as the IAN are promising.

An additional limitation of the ECLS-B is the use of a wide age range at assessment for children at the 9-month and 2-year time points. While standardized measures such as the *BSF-R* account for age at assessment, parent report and observer rating of child behavior may be affected by a wide age range. As previously noted, the ages of the children with ASD were very close in age to the stated mean, with minimal variation. While appropriate weights and controls for the assessment age were included in our analyses to minimize the effect of the wide age ranges, there is a possibility that some children over 24 months at the 2-year time point (range for children with ASD = 22.9-28.9 months) may have received a

provisional diagnosis of ASD with a concurrent effect on the skills and behaviors reported by parents. The 2-year time point parent survey provided an "other" category in questions about disability, but the absence of a survey question specific to ASD may have missed some children with provisional diagnoses.

With the 15-month age gap between the first two time points (9 months and 2 years), the ECLS-B data set was not optimal for identifying early predictors of ASD below the age of 2 years. An additional time point at 15 or 18 months of age may have helped identify additional predictors. This would be especially useful for identifying social communication differences in the toddler years (Wetherby et al., 2004).

## Implications for Research

As a longitudinal study, school data from the ECLS-B hold the possibility that more children will be identified with higher functioning forms of ASD at kindergarten and that retrospective information can strengthen insights into early predictors. Perhaps more importantly, with the vast majority of children with ASD receiving speech and language services in our study, it would be interesting to examine their reading and language skills in the early school years.

For children with ASD, significant early predictors of deficits in the core areas of communication and social interaction were found at the 2-year time point. Research that explores these skills in-depth at 15 to 18 months is warranted, given that parents often express concerns about their children at these earlier times. For parents with children who are not communicating and have a very limited repertoire of words by 2 years of age, the foundational work provided by the current study reinforces the urgency to seek the assistance of speech/language professionals.

When looking at the two disability categories, children with and without ASD, it is clear that there is a wide variation in the functional abilities of children who are found within these groupings. Future research comparing children according to their functional abilities or severity of their disability would be a possibility with the information provided in the ECLS-B data set.

Health characteristics of children with ASD, particularly the occurrence of epilepsy, ear infections, and gastrointestinal concerns, are in need of further research. For example, the ECLS-B data set includes parent report of ear infection treatments (e.g., ear drops, ear tubes, antibiotics), which may provide useful information on early medication exposure. By identifying associated impairments in children with ASD, researchers are able to develop medical and educational intervention strategies suited for optimal outcomes. With the large number of interventions flooding the media for use in the treatment of behaviors and characteristics of ASD, it will be important to ground all interventions in research-based best practices.

## Implications for Practice

The *MCHAT* (Robins et al., 2001) and the *Communication and Symbolic Behavior Scales Developmental Profile, Infant-Toddler Checklist* (Wetherby et al., 2004) are two screening tools currently used for identifying possible ASD in toddlers. Using our study's

additional early predictors of ASD, it might be helpful to gather additional information beyond those screening tools, particularly when screening 2-year-old children. In extending the capability of current screening tools, additional questions could include (a) number of words spoken; (b) number of ear infections; (c) presence of behaviors of fearfulness, frustration, and lack of cooperation; (d) presence of epilepsy or seizures; (e) tendency to quickly cry or change moods; and (f) fine and gross motor concerns. Likewise, with the marked increase in diagnosis of ASD, pre-service early childhood professionals could benefit from information about behaviors and characteristics of young children with ASD.

As the literature indicates, early identification of ASD carries the implication that the earlier intervention is begun, the better the outcomes for children and their families (Boyd, Odom, Humphreys, & Sam, 2010). The results of much of our analyses provide evidence of early predictor characteristics that appear by the age of 2 and would assist in the diagnosis of ASD. Thus, waiting until 3 or 4 years of age for diagnosis (Filipek et al., 1999; Goin & Myers, 2004; Zwaigenbaum et al., 2009) creates a loss of optimal time. Understandably, the hesitation to diagnose is based on the notion that labeling a child at a very young age is an indicator of a lifelong disability, along with associated difficulties for family and child. Perhaps instead, the view should be taken that earlier intervention may ameliorate the most difficult symptoms and behaviors associated with ASD and markedly improve the lifetime outcomes. With the push for at least 2 years of intensive intervention (Filipek et al., 1999), the early years seem a prime time for intervention, before the difficulties associated with attending school appear.

Evidence from the current study suggests that by the age of 2 years, it is possible to distinguish children with ASD from their peers with disabilities as well as those who are typically developing. Clearly, delays and difficulties are present at this early age, and young children with ASD struggle with their ability to communicate and socially interact with others. In addition, we found that, at the age of 2 years, children with ASD have more ear infections, have the risk of epilepsy, have difficulty with self-regulation, and have gross and fine motor concerns. In addition, these various predictors distinguished children with ASD from the other groups even after controlling for the influence of multiple demographic factors. It should be noted that the mothers of children with ASD in our study not only identified their children as difficult to raise but also often sought early intervention services.

Pertinent to any discussion regarding the early characteristics of ASD is the current publication released for diagnosing autism, the *DSM-5*, in which the traditional triad of communication deficits, social interaction deficits, and restricted, repetitive behavior are replaced by a dyad of social communication and interaction, in addition to repetitive and restricted behavior. Several diagnosed conditions, including Asperger syndrome and Pervasive Developmental Disorder–Not Otherwise Specified (PDD-NOS), have become classified under the single title of autism. Individuals will need three different types of social communication impairment and two of four repetitive and restricted behaviors to meet the new criteria (APA, 2013). With the requirement that symptoms must be present in early childhood, our study adds to the research of characteristics apparent in the early years of a nationally representative group of children with ASD.

We still have much to learn about ASD and its effects on both the child and the family. The current study is the first to look at the characteristics and behaviors of the children with ASD as reported by parents and assessed by professionals prior to the diagnosis of

the disability. The data collection occurred "in the moment" rather than relying on parental memory and gives an accurate representation of the children with ASD in their early years. Using a wide range of variables and multiple time points, our study addresses the gaps in the literature to create a composite of characteristics of children with ASD. It is hoped that with early and accurate diagnosis, the most appropriate intervention strategies can be found that will have long-lasting effects on the outcomes of young children with ASD and their families.

# Appendix

## Psychometric Properties of Measures used in ECLS-B Data Set

The ECLS-B data collection involved a variety of techniques, including self-administered parent questionnaires (in hard copy), computer-assisted personal interviews of parents (CAPIs), direct child assessments during an in-home visit by trained interviewers, and field observations of the child's behavior during the home visit. Direct assessments by the interviewers were completed in a hard-copy child activity booklet during the assessment. The psychometric report of the measures provided by NCES can be found at http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2007084

In a videotaped portion of the child assessment, a short interaction between the mother and child was recorded for the *Nursing Child Assessment Teaching Scale* (*NCATS*; Sumner & Spietz, 1994). The *NCATS* tapes were sent to the coding staff at Westat® (a research data collection and management company) to be coded on *NCATS* forms. The *NCATS* was designed for use with young children from birth to 3 years of age. The scale is used to observe and record caregiver–child interactions during a novel situation for the purpose of assessing the dyad's strengths and areas in need of improvement. The *NCATS* consists of six subscales, with four describing the parent's behavior during the interaction (Sensitivity to Cues, Response to Distress, Social-Emotional, and Cognitive Growth Fostering) and two describing the child's behavior (Clarity of Cues and Responsiveness to Caregiver).

The *NCATS* scores were found to be predictive of various measures of subsequent child functioning, including expressive language, receptive language, and infant attachment (Sumner & Spietz, 1994). Sumner and Spietz reported internal consistency reliability (Cronbach's α): ranged from .52 to .80 on the caregiver subscales, .50 on the child's Clarity of Cues, and .78 on the child's Responsiveness to Parent subscales. The reliability alphas for the total caregiver and child subscales were .87 and .81, respectively. For test–retest reliability (with a 3- to 4-month interval between tests), .85 on the total parent score and .55 on the total infant score were reported. According to Sumner and Spietz (1994), the concurrent validity of the *NCATS* caregiver scores was tested against the *Home Observation for Measurement of the Environment (HOME) Inventory* (Caldwell & Bradley, 1984) and the *Bayley Scales of Infant Development* (Bayley, 1993). The correlations of the total *NCATS* scores with the total *HOME* score among children ages 1 to 36 months, in three age groups, ranged from .41 to .44. The correlations of the total *NCATS* score with the *Bayley Mental Development Index (MDI)* and *Bayley Psychomotor Development Index (PDI)* were .28 and .34, respectively. In addition, the *NCATS* caregiver scales were more strongly correlated with the *HOME* and *Bayley Scales*. Likewise, in a

test for predictive validity, correlations of .23 and .34 were reported between *NCATS* total scores taken at 3 and 10 months and *MDI* scores, both of which were statistically significant. The subscale correlations ranged from −.01 to .37. Correlations between the *NCATS* caregiver and total scores at 24 months with the *Bayley MDI* (at 24 months), *Preschool Language Scale–3* (*PLS-3*; Zimmerman, Steiner, & Pond, 1992; at 36 months), and the *Wechsler Preschool and Primary Scales of Intelligence* (*WPPSI IQ*; Wechsler, 1989; at 60 months) were consistently strong. With permission from the publisher (Psychological Corporation), the *Bayley Short Form–Research Edition* (*BSF-R*), a shortened form of the *Bayley Scales of Infant Development–Second Edition* (*BSID-II*; Bayley, 1993), was created for use in the ECLS-B data collection (Andreassen & Fletcher, 2007). The *BSF-R* comprised of a subset of items from the *BSID-II*, which was used to estimate performance on the full *BSID-II* and was able to be administered in the home by trained interviewers. This subset of items, selected to approximate children's performance on the full *BSID-II*, was chosen using Item Response Theory (IRT) modeling as described in the "Early Childhood Longitudinal Study, Birth Cohort (ECLS-B): Psychometric Report of the 2-Year Data Collection" (Andreassen & Fletcher, 2007). The *BSID-II* has been used frequently in research studies needing a psychometrically sound assessment tool for infants and young children. Bayley (1993) reported high internal reliability, measured by average coefficient alpha, across age ranges (i.e., .88 on the MDI, .84 on the PDI, and .88 on the BRS). Over a median interval of 4 days, the test–retest reliability was high for the Mental Scale ($r$ = .87) and adequate for the Motor Scale ($r$ = .78). Content validity was addressed in the *BSID-II* by a survey of the original *BSID* users, literature review, panel review by experts in child development, new item generation, three pilot testings, and bias analysis using Rasch techniques and expert panel bias review.

Andreassen and Fletcher (2007) described the rigorous procedure of item selection to reduce the number of items from the *BSID-II* for the *BSF-R*, and noted that the *BSF-R* Mental Scale was estimated to have an overall reliability of $r$ = .978 and the Motor Scale was estimated to have an overall reliability of $r$ = .973. The overall IRT reliability coefficient obtained with ECLS-B observations was $r$ = .975 for the *BSF-R* Mental Scale and $r$ = .969 for the Motor Scale. The standard error of the Mental Scale score ranged from 2.378 to 8.294 and the standard error of the Motor Scale score ranged from 1.624 to 5.421 on the *BSF-R.*

The *BSID-II* uses a 30-item BRS to help interpret children's performance during assessment. While nine items were chosen from the *BRS* and included in the ECLS-B for this purpose, Andreassen and Fletcher (2007) noted that these were not meant to approximate the full *BRS*. In the current study, the behavior items were standardized and averaged at each time point to create a composite score.

The Parent Interview questions for Self-Regulation and Sleep Patterns came from the *Infant/Toddler Symptom Checklist* (*ITSC*; DeGangi, Poisson, Sickel, & Wiener, 1995). The original checklist is a screening tool designed to obtain information about children's self-regulatory behaviors and sensory integration. The items selected for the ECLS-B were identified in the *ITSC* manual as those most successful at differentiating children with regulatory disorders from children without these disorders. According to DeGangi and colleagues, in a comparison for predictive validity, 78% of infants identified by the ITSC as having problems were diagnosed with developmental or behavioral problems at 3 years of age using standardized measures such as the *Child Behavior Checklist* (*CBCL*, Achenbach,

1992). It should be noted that the normative sample used for the *ITSC* consisted of White middle class infants and toddlers. The authors report false positives are between 0.03 and 0.13 and false negatives are between 0.00 and 0.14.

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