Autism spectrum disorder severity as a predictor of Battelle Developmental Inventory – Second Edition (BDI-2) scores in toddlers

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Abstract

Objective: The study aimed to evaluate the relationship between the severity of autism spectrum disorder (ASD) symptomology and scores on the Battelle Developmental Inventory, Second Edition (BDI-2) in toddlers (n = 325).

Methods: Total scores on the BDI-2 and individual domain scores were examined to explore the relationship between severity of ASD and developmental quotient, impairment in personal-social skills, adaptive functioning, cognition, and communication.

Results: Regression analyses controlled for the impact of age and IQ on results, indicating that higher autism severity scores were associated with overall greater impairment and in the total scores and the individual domains of the BDI-2. The domains were found to be differentially affected by severity of ASD.

Conclusion: These findings suggest severity of ASD may influence symptom presentation. Clinical implications of study findings are discussed.

Keywords

ASD, Battelle Developmental Inventory, Second Edition (BDI-2), symptom severity

Introduction

Defining features of autism spectrum disorder (ASD) include deficits in socialization and communication as well as the presence of restricted interests and stereotypes [1–6]. Although not characteristic features, those with ASD often also have difficulties in functional areas such as self-help and adaptive skills (e.g., dressing, toileting, sleeping, eating; [7–9]), motor skills and coordination [10, 11], and cognitive functioning [12]. The high prevalence and chronic nature of ASD make it a high priority for study [13].

Treatment of core symptoms as well as related symptoms, as discussed above, are thought to be of critical importance, with a specific focus on early intervention [14, 15]. Some of the factors which can predict effectiveness of early intervention include age, functioning level, and amount of intervention [16, 17]. Because of the focus on early treatment, early identification of ASD has been of utmost importance [18], and investigation of infants and toddler characteristics in the ASD population has increased in recent years [19–22].

Because intellectual disability (ID) has been found to be a negative prognostic indicator for those with ASD, and because early treatment is ideal, it is important to be able to estimate cognitive functioning in infants and toddlers [23]. The correlation between rates of ASD and rates of ID are high, with estimations being in the range of 50–70% [24]. However, the use of standard intelligence assessments to reliably assess IQ in infants and toddlers is not possible since IQ is not stable at these early ages [25]. Therefore, diagnostic quotient (DQ) and the specific domains of the DQ are often used to estimate development and examine different facets of developmental impairment in very young children.

Severity of ASD symptoms in toddlers has been studied relative to several different comorbid problems. More severe ASD was associated with problems with attention and impulsivity [26], higher rates of challenging behavior, stereotypic behavior and self-injurious behavior [27, 28], and more severe anxious and avoidant symptoms [29]. Further research investigating how ASD severity is related to other areas is warranted because those diagnosed with ASD often present with a multitude of symptoms in addition to social and communication deficits (diagnostic features) including deficits in cognitive abilities, motor skills, and self-help skills which may be related to ASD severity. Additionally, investigations regarding the effect of ASD severity on developmental level are of further interest. Therefore, the purpose of this current study was to examine whether severity of ASD could predict total scores on the BDI-2 and individual domain scores. It was hypothesized that severity of ASD would significantly predict all BDI-2 scores.

Methods

Participants

The current study included 325 participants between the ages of 17–36 months (M = 26.43, SD = 4.43). The sample was obtained via EarlySteps, Louisiana’s state-funded early intervention program, which provides services to infants and
toddlers from birth to age 36 months and their families under the Individuals with Disabilities Education Act, Part C. All participants had diagnoses of ASD which were made by a licensed clinical psychologist with over 30 years of experience. Diagnoses were based on clinical judgment and experience using a variety of measures including the Baby and Infant Screen for Children with uTism Traits (BISCUIT), the Modified Checklist for Autism in Toddlers (M-CHAT) and a DSM-5 criteria algorithm for autism spectrum disorder. Ethnicity of the participants was reported to be 46% Caucasian, 45.7% African American, 2% Hispanic, and 6% were not identified. 76.4% were male and 23.6% were female. See Table I for demographic information.

### Measures

Battelle Developmental Inventory, Second Edition (BDI-2). The BDI-2 is a 450-item measure which assesses children from birth to age 7 years 11 months on personal/social, adaptive, motor, communication, and cognitive development [30]. Items are scored from 0 to 2 (0 = no ability in this skill, 1 = emerging ability, 2 = ability at this skill). The BDI-2 has been found to have acceptable test–retest reliability of $\alpha = 0.80$ [31], as well as excellent internal consistency of 0.98 to 0.99 [30].

Baby and Infant Screen for Children with uTism Traits-Part 1 (BISCUIT-Part 1). The BISCUIT is a three-part battery which measures symptoms of ASD and associated problems in infants and toddlers aged 17–36 months. Part 1 of the BISCUIT which measures the core symptoms of ASD was used in the current study. Part 1 is comprised of 62 items that are rated by primary caregivers using a 3-point Likert scale ranging from 0 to 2 (0 = not different; no impairment, 1 = somewhat different; mild impairment, and 2 = very different; severe impairment). A total score falls into one of three categories: no autism/atypical development (below 17), possible ASD/PDD-NOS (18–34), or probable ASD/PDD-NOS (35 or higher). Total score on this measure was utilized as a measure of ASD symptom severity. The BISCUIT-Part 1 has been found to have sound psychometric properties (i.e. internal reliability of 0.97; [32], and an exploratory factor analysis revealed a three factor structure: socialization/non-verbal communication, repetitive behaviors/restricted interests, and communication [33]. The scale also has excellent sensitivity and specificity [32].

The current study was approved by the Louisiana State University Institutional Review Board. Informed consent was obtained prior to the administration of measures.

### Research design

Participants with missing data were excluded from the study. Potential participant differences of the demographic data were not examined $a priori$ or added as covariates to the analysis, because it is well established that ASD is more common in males than in females [34]. Additionally, age was not entered as a covariate because the developmental quotient scores were used which adjusts for age. Finally, ethnicity was not entered as a covariate because it is also well established in the literature that different ethnicities exhibit similar presentations of ASD [35].

A simple regression was first conducted with ASD severity as the IV and BDI-2 total developmental quotient score as the DV. Next, a multivariate regression analysis was conducted with ASD severity as the IV and individual domain developmental quotient scores of the BDI-2 as the DVs, to examine relationship between severity of ASD and scores in the BDI-2.

### Results

The simple linear regression conducted, with ASD severity as the IV and total developmental quotient scores as the DV, showed that ASD severity significantly predicted total scores on the BDI-2, $R^2 = 0.128$, $F (1, 324) = 47.48$, $p < 0.001$. Higher autism severity scores were associated with overall greater impairment in the study participants.

The significant result of this regression was followed up with a multivariate regression to examine whether autism severity predicted total scores on the individual domains of the BDI-2: Adaptive, Personal-Social, Communication, Motor, and Cognitive. In the multivariate regression, autism severity was entered as the IV and the domains of the BDI-2 were entered as DVs. The multivariate regression model was significant for all five domains of the BDI-2, meaning that ASD severity significantly predicted scores on each domain of the BDI-2 over and above the effects of the overall DQ. ASD severity best predicted scores on the Personal-Social domain, $R^2 = 0.157$, $F (1, 324) = 60.08$, $p < 0.001$. The Adaptive domain was the next domain best predicted by ASD severity, $R^2 = 0.094$, $F (1, 324) = 33.65$, $p < 0.001$, closely followed by the Cognitive domain, $R^2 = 0.093$, $F (1, 324) = 33.05$, $p < 0.001$. The Motor domain was the fourth best predicted domain by ASD severity, $R^2 = 0.080$, $F (1, 324) = 28.16$, $p < 0.001$. Finally, ASD significantly predicted total scores on the Communication domain, $R^2 = 0.069$, $F (1, 324) = 23.80$, $p < 0.001$. See Table II for effect sizes.

### Discussion

The current study examined whether severity of ASD predicted total scores on the BDI-2 and the individual domains of the BDI-2. The results of the regression and multivariate regression analysis revealed that severity of ASD significantly predicted total scores on the BDI-2 and the individual domain scores. However, results indicated that the domains of the BDI-2 are differentially affected by severity of ASD.

Our findings are consistent with other research that more severe ASD is associated with an overall more impaired...
symptom presentation [36–42]. Symptom severity of ASD accounted for 13% of the total variance for overall BDI-2 scores. Interestingly, the individual domains of the BDI-2 were each significantly predicted by severity of ASD but, each accounted for a different amount of variance.

ASD severity best predicted scores on the Personal-Social domain, accounting for 15.7% of the total variance. These results support previous findings illustrating a relationship between ASD symptomology and personal-social symptoms [43]. The Personal-Social domain is made up of subdomains which assess adult interaction, peer interaction, self-concept, and social role. This domain may be best predicted by severity of ASD symptoms, because it captures the core symptoms of ASD: impairments in social interactions and relationships. Furthermore, the Personal-Social domain may account for the greatest amount variance because it is affected the most by the other domains. For example, Sipes, Matson and Horovitz (2011) [44] found that children with greater motor skills had fewer socialization impairments. Motor skills may be necessary for children with ASD to carry out social tasks [45–47]. Thus, the large amount of variance accounted for by this domain suggest an interconnected of symptoms assessed by all domains of the BDI-2.

The Adaptive domain, which assesses self-care and personal responsibility, and Cognition domain, which assesses attention and memory, reasoning and academic skills, and perception and concepts, were also found to have a significant relationship with overall severity of ASD. ASD severity accounted for 9.4% and 9.3% of the variance in the Adaptive domain and the Cognitive domain, respectively. The amount of variance accounted for by the two domains is similar. This finding is in accordance with previous research that adaptive functioning is highly correlated to cognitive level and symptom severity [32, 48–52]. Baghdadi et al. (2012) [48] found using the Vineland Adaptive Behavior Scale [53], that ASD severity predicts a similar amount of variance in the Adaptive domain and the Cognitive domains which were closely tied in the ASD population.

One explanation for the significant finding of the Adaptive domain may be that the more severe an individual’s symptoms of ASD are, the lower functioning overall they tend to be, thus it is harder for them to care for themselves [54]. With regard to the Cognition domain, this finding may be explained by research showing that severity of ASD is related to level of IQ [55]. Autism severity has been found to increase with decreasing IQ [56].

Eight percent of the overall variance was predicted by the Motor domain, which assesses gross motor, fine motor, and perceptual motor skills. This finding indicates that motor deficits are explained by ASD symptom severity to a moderate degree. This finding corroborates research by Green et al. (2009) [57], that children with more severe ASD symptomatology had greater motor skill impairments than children with less severe ASD symptomology. Furthermore, children with an IQ below 70 had more motor impairments than children with IQs above 70. Collectively, these findings suggest that severity of ASD plays a role in degree of symptom impairment possibly as a result of the neurological impairments that contribute to ASD.

Finally, the Communication domain which assesses receptive and expressive language, accounted for 6.9% of the overall variance. In line with findings from previous studies, an individual’s level of communication was associated with severity of ASD symptoms [48]. Additionally, the absence of language abilities is related to severity of ASD symptoms and cognitive functioning. Research in the area has found that receptive and expressive language can be predicted by severity of ASD symptoms [58, 59]. Liss et al. (2011) [60] also demonstrated this finding when comparing children with ASD to typically developing age matched peers. They found that those with ASD were more significantly impaired in socialization and daily living but not communication. It should be noted that the Communication domain accounted for the least amount of variance compared to the four other domains. Perry, Helen, Geier, and Freeman (2009) [43] provided one explanation for this finding. Perry, Flanagan, Geier, and Freeman (2009) [43] suggested that less variance was accounted for by communication skills because cognitive level subsumed much of that variance.

The current study provides support for the notion that symptoms of ASD are not mutually exclusive. The amount of variance accounted for by each domain seems to be closely related to and possibly affected by the other domains. For example, Liss et al. (2011) [60] found that cognition is related to other components of autism symptomatology: reciprocal social interaction, empathy, repetitive and restricted play, stereotypies, repetitive and restricted interests, communication impairments, eating habits and, regression of speech. For this reason, it would be interesting in the future to examine whether IQ and autism symptomology predict scores on the BDI-2 and to examine if there is an interaction between autism symptomology and IQ in relation to scores on each domain of the BDI-2? Does IQ and severity of symptoms affect the domains differently?

From a treatment perspective, these findings are important. The severity of symptom presentation of ASD should be measured when designing intervention programs and planning intensity of treatment [61, 62]. Lower functioning individuals will generally require more intensive treatment. Furthermore, a well-rounded treatment program is important, as we found that the symptoms assessed by the domains of the BDI-2 affect each other [63, 64]. For instance, targeting motor skills may indirectly improve an individual’s personal-social skills. Accurate and early assessment of severity of ASD is crucial for proper intervention planning and treatment.

**Declaration of interest**

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this paper.


