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An investigation of the association between seizures, autism symptomology, and developmental functioning in young children

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ABSTRACT

Objective: The aim of the present study was to explore whether a history of seizures was associated with autism symptom severity and developmental functioning in young children.

Methods: Autism symptom severity and developmental functioning were compared between children with and without a history of seizures who either had atypical development or met criteria for autism spectrum disorder (ASD) based on review of records by a licensed clinical psychologist.

Results: Parents of children who met criteria for ASD reported lower levels of autism symptomology when the child had a history of seizures, while the opposite trend was found for children with atypical development. Participants without ASD or seizures had greater developmental functioning than the other groups.

Conclusion: The present study emphasizes the need for early identification and diagnosis of both ASD and seizure disorders, as timely intervention for these two conditions may be related to improved outcomes for young children.

As the prevalence of seizures may increase with age in individuals with ASD, several researchers have investigated the average age at onset, with somewhat discrepant findings. For example, Hara and colleagues found that the average age of emergence of seizures was 14 years of age. Similarly, the results of a study by Bolton and colleagues indicated an average of approximately 13 years. These authors suggested that age-related neurological development may account for the later emergence of seizures in individuals with ASD.

Conversely, other researchers have found younger ages at onset. For example, Mouridsen and colleagues found that the average age was approximately 8 years. Comparably, Danielsson and colleagues reported a very similar average of 7.5 years. They also found a very early age of onset (i.e., prior to 24 months of age) for approximately one-third of participants. Their results further indicated that the risk for developing epilepsy is greater early in life and decreases with age.

Several theories proposed by researchers lend support to the idea that there may be two “peak” age ranges for onset of seizures, one early in childhood and one later in life. Nomura and colleagues suggested that these peaks were in early childhood around approximately 3 years of age and late adolescence at approximately 16–17 years. Further, Matson and Neal suggest an initial age of 5 years and later age of 10. This theory that there are two “peaks,” one early in childhood and one later in childhood or adolescence, may help to explain the discrepancies between other studies.

Numerous studies have been published on whether the age of onset is related to other variables, such as level of intellectual functioning. While some researchers have posited that...
age of onset is not significantly associated with intellectual or adaptive functioning, others have found that children with seizure onset prior to ages 2\(^7\) or 5\(^28\) may have greater cognitive impairments than those with onset later in childhood. Interestingly, Berg and colleagues\(^9\) suggested that the association between impairment in cognitive functioning and age at seizure onset may be more significant early in childhood and decrease with age.

Other than age, several additional variables have been implicated in the risk for seizures in individuals with ASD. These include, though are not limited to, intellectual functioning, gender\(^5,30\), and symptom severity. Much of the literature suggests that seizures are more prevalent in individuals with lower cognitive or intellectual functioning.\(^5,6,10,13–15,30\) Additionally, females are at an increased risk of developing seizures as compared to males.\(^5,30\) The findings of Amiet and colleagues\(^30\) and Bolton and colleagues\(^5\) suggest that the prevalence of seizures is estimated to be between 30–34.5% of females and 18–18.5% of males with ASD. Danielsson and colleagues\(^6\) results support this assertion, with estimates of 58% of females and 32% of males with ASD. In relation to autism symptomology, Gabis and colleagues\(^13\) found that based on DSM-4 criteria, children with autism were more likely to have seizures than those with Asperger syndrome and therefore, seizures were more prevalent in children in the more impaired range of ASD.

However, there is some evidence that cognitive functioning may be the construct that underlies all of these associations. The findings of Viscidi and colleagues\(^15\) indicated that more severe autism symptomatology was not significantly associated with epilepsy after intelligence quotient was taken into account. Further, there is evidence that females diagnosed with ASD may be more likely to have lower cognitive functioning, which may be related to the higher rates of seizures.\(^6,13,19\) Given the potential implications of cognitive impairment on these other factors, additional research on what variables may increase individuals’ risk for seizures is warranted.

A better understanding of this relationship may also have clinical implications for the assessment of epilepsy in this population, as it is possible that symptoms of ASD (e.g., deficits in response to social stimuli and repetitive motor movements) may obscure seizure symptoms and therefore delay diagnosis of seizure disorders.\(^10,19\) Alternatively, symptoms associated with seizures may mimic certain behavioral traits associated with ASD, such as not responding to one’s name or staring spells that could be attributed to lack of response to environmental stimuli.\(^19\)

El Achkar and Spence\(^31\) summarized previous findings on ASD screening outcomes in children with epilepsy and noted that although high number of children with epilepsy screened positive for ASD, a much lower percentage received a diagnosis upon comprehensive evaluation. This emphasizes the importance of consideration of differential diagnosis, as concerns such as greater developmental delay may increase the likelihood of children with epilepsy screening positive on ASD screeners.\(^32\) Therefore, comprehensive training for professionals conducting diagnostic assessments in how to differentiate between symptoms of ASD, developmental delay, and seizure indicators is warranted for timely and accurate diagnosis.

The current study aims to further investigate the association between seizures in young children with ASD and autism symptomology. Although the relationship between seizures and intellectual disability has been well documented, few studies have investigated ASD symptomology in children with comorbid ASD and epilepsy. Four classifications were utilized and were determined by whether the child met DSM-5 criteria for an ASD diagnosis based on record review by a licensed clinical psychologist and whether the individual had a parent-reported history of seizures. The groups were compared to explore the potential relationship between ASD symptom severity and/or specific symptoms (i.e., socialization/nonverbal communication, repetitive behavior/restricted interests). Differences in developmental functioning were also examined across groups to investigate whether patterns in this sample were consistent with findings in previous studies (i.e., that individuals with seizures had lower developmental functioning than those without seizures within each group). The current study also aims to advance the current literature by utilizing a sample of young children (i.e., 37 months of age and younger).

**Method**

**Participants**

Participants’ data for this study were extracted from a preexisting database of de-identified records of children enrolled in Louisiana’s early intervention program, EarlySteps, under the Individuals with Disabilities Education Act, Part C. Children are eligible for participation if they are under 3 years of age and are determined to be at risk for a developmental delay or medical condition. The dataset consists of assessment information for these children. Consequently, all participants in this study were between the ages of 17 and 37 months and were suspected of evincing some form of atypical development. All children enrolled in EarlySteps receive service coordination. As of January 2017, 16% of children enrolled received special instruction, 45% received special instruction, 16% received speech therapy, 25% received occupational therapy, and 13% received physical therapy through the EarlySteps program. A small percentage (i.e., 1–2%) received other services such as counseling, nursing, nutrition, audiology, vision, and psychology.

Participants were categorized as falling into one of four groups based on whether they had a history of seizures and met DSM-5 criteria for ASD: an atypical development group without a history of seizures (ATYP), an atypical development group with a history of seizures (ATYP + SEIZ), an ASD diagnosis group without seizures (ASD), and finally a comorbid ASD and seizures group (ASD + SEIZ). A licensed clinical psychologist with over 30 years of experience in the field assigned ASD classifications in accordance with the Diagnostic and Statistical Manual, Fifth Edition (DSM-5\(^5\)) criteria for ASD based on a comprehensive review of records. These procedures were consistent with diagnostic methodology described in the literature for research purposes.\(^33\) Report of any current diagnosis of a seizure disorder/seizures by the parent or caregiver on the medical history portion of the
demographic section of the Baby and Infant Screen for Children with Autism Traits (BISCUIT)\textsuperscript{34} was used to determine if the participant had a history of seizures or a seizure disorder.

The original dataset consisted of data for a total of 17,996 participants. Participants were included in the present study if parents had completed the ASD screening (i.e., BISCUIT-Part 1) and if there was no missing data. Deletion of cases with missing data was employed rather than estimation of missing data because the smallest group (ASD + SEIZ) did not contain any participants with missing data, and as such deletion did not decrease the final sample size. \textsuperscript{35} Some participants received annual evaluations through EarlySteps, and for participants with more than one record, data from the most recent assessment were utilized. The number of cases excluded is presented in Figure 1. The number of records eligible for inclusion in the study was 9,410, with 8,164 ATYP, 1,024 ASD, 174 ATYP + SEIZ, and 48 ASD + SEIZ. Given the disparate sample sizes, age and gender matching was applied because of the potential relationship between these demographic variables and the presence of seizures. The ATYP, ATYP + SEIZ, and ASD groups were age and gender matched to the smallest group, ASD + SEIZ. There was no exact age match for one participant in the ATYP + SEIZ group for age; so, this case was matched within 1 month of the participant in the ASD + SEIZ group (i.e., 24 rather than 23 months of age). Matching resulted in 48 participants in each of the four groups, and so a total of 192 participants were included in the present study. All participants were between 17 and 35 months of age (\(M = 25.89, SD = 4.59\)), and 58.3\% were male (\(n = 112\)) while 41.7\% (\(n = 80\)) were female. In regard to race, 47.9\% of participants were African American (\(n = 92\)), 42.2\% were Caucasian (\(n = 81\)), 4.2\% were Hispanic (\(n = 8\)), and 5.7\% were of another race (\(n = 11\); see Table 1 for group demographic information).

**Measures**

**Baby and infant screen for children with autism traits**

The BISCUIT is a parent or caregiver-report measure for children 17–37 months of age that is composed of three subscales (i.e., ASD symptomology, comorbid psychopathology, and problem or challenging behaviors\textsuperscript{34}). The BISCUIT-Part 1 has 62 items and measures autism symptoms related to Socialization/Nonverbal Communication, Restricted, Repetitive Behavior and Interests (RRBI), and Communication. Each item is scored based on a 3-point Likert scale that compares the participant to same-aged peers or level of impairment (i.e., 0 = “not different; no impairment;” 1 = “somewhat different; mild impairment;” and 2 = “very different; severe impairment”). A score of 17 or greater falls in the “at risk” range. There are 24 items in the Socialization/Nonverbal Communication subscale and 23 in the Repetitive Behavior/Restricted Interests subscale. The Communication subscale consists of seven items. The internal reliability has been estimated to be .87, and the measure has a correct classification rate of .89. This measure has been shown to have convergent validity with the Personal-Social domain of the Battelle Developmental Inventory, Second Edition (BDI-2), and the Modified Checklist for Autism in Toddlers (M-CHAT) as well as divergent validity with the Adaptive and
Motor domain on the BDI-2. The present study included information from the demographic form, the Part-1 total score, and domain scores for Socialization/Nonverbal Communication and RRBIs. The Communication subscale was excluded as many of the participants included in the early intervention sample had expressive communication delays, and language delays are no longer a required criterion for an ASD diagnosis under DSM-5. The demographic form was used to collect demographic information and developmental and medical information (i.e., history of seizures or epilepsy).

**BDI-2**

The BDI-2 is a 450-item measure of development functioning used for children 7 years of age and younger. It includes a score for emerging ability, and 2 = "ability"). Test–retest reliability has been estimated at .90, internal consistency for total developmental quotient (DQ) at .99, and convergent validity has been demonstrated with the Bayley Scales or Infant Development, Second Edition and the Preschool Language Scales. The present study included only participants' total development quotient.

**Procedure**

The data utilized in the present study were acquired from a large research database of de-identified archival records. The Institutional Review Board determined that informed consent was not required since all identifying information (e.g., name, date of birth, zip code) was removed from the record by Louisiana's Office for Citizens with Developmental Disabilities prior to receipt by the researchers. The use of this data for research purposes was approved by both the State of Louisiana's Office for Citizens with Developmental Disabilities and the Louisiana State University institutional review board.

All assessments were conducted through the EarlySteps program, Louisiana's early intervention system, and parents had the option to receive an autism screening (i.e., BISCUIT-Part 1) as part of their assessment. If they preferred not to receive the screen, parents completed and signed a refusal form indicating that they did not wish to have their child screened for ASD at that time. Autism screenings consisting of the BISCUIT-Part 1 were administered in the child's home or daycare by service providers who had received training on the measures administered. These providers also held a degree, licensure, or certification in several fields such as physical therapy, occupational therapy, speech-language pathology, special education, or psychology. The evaluation was comprised on a battery that involved caregiver interviews as well as direct observation. Data recorded between January 2010 and October of 2016 were utilized in the study.

**Statistical analyses**

As the groups were gender and age-matched to the smallest group (i.e., ASD + SEIZ, n = 48), bivariate comparisons of these demographic variables were not conducted. However, as groups were not matched for race, a chi-square analysis was conducted to assess differences between groups. To investigate the connection between group and total ASD symptom severity, an analysis of variance (ANOVA) was run with group (i.e., ATYP, ATYP + SEIZ, ASD, and ASD + SEIZ) as the independent variable (IV) and ASD symptom severity (i.e., total score on the BISCUIT-Part 1) as the dependent variable (DV). Post-hoc tests were utilized to provide additional investigate of specific group differences. A multivariate analysis of variance (MANOVA) was run with group as the IV and scores from the two autism symptom subscales, Socialization/Nonverbal Communication and Repetitive Behavior/Restricted Interests, were the DVs. Post-hoc comparisons were conducted to further investigate these group differences. Lastly, an ANOVA was also conducted to investigate differences in total developmental functioning, as assessed by the total BDI-2 score, across groups and was accompanied by post-hoc comparisons. Two participants in the ATYP group were missing scores for the BDI-2; so, these participants were excluded from the present analysis and the sample size of the ATYP group was 46 rather than 48.

**Results**

A chi-square analysis did not indicate significant differences in race between groups, $\chi^2 (9) = 14.49$, $p = .106$. Table 2 presents the means and standard deviations of total BISCUIT Part-1 scores, total subscale scores, and total BDI DQ for all four groups. Prior to analysis of the BISCUIT-Part 1 scores, the data were examined for outliers. Outliers were found in the ATYP and ASD + SEIZ groups (as determined by inspection of boxplots for values greater than 1.5 lengths), and since the scores were moderately positively skewed, a square root transformation was applied. The ANOVA on total symptom severity indicated significant differences.
between groups, $F(3, 188) = 87.35, p > .001$, partial $\eta^2 = .582$. Tukey’s post-hoc tests were conducted, as Levene’s test of equality of error variance was not significant ($p = .051$). The results of post-hoc tests revealed that all groups differed significantly on total scores on the BISCUIT-Part 1 total score (ASD and ASD + SEIZ, $p = .002$; all others $p < .001$). The ASD group had the highest average scores, followed by the ASD + SEIZ group, then the ATYP + SEIZ group, and the ATYP group had the lowest scores (see Table 2).

Logarithmic transformations were applied to the Socialization/Nonverbal Communication and RRBIs domain subscales because univariate outliers were identified and the data for both subscales were strongly positively skewed. A MANOVA using this transformed data was conducted to investigate differences between groups on symptom domains. Box’s test of equality of covariance matrices was significant, indicating that the assumption of homogeneity of covariance matrices was violated ($p < .001$). Given the equal sample sizes, this violation was not substantially concerning; however, to be conservative, Pillai’s Trace was used because it is less sensitive to violations of assumptions.\(^{38,39}\)

Using Pillai’s trace, significant differences were found for symptoms in the two subscales across groups $V = .621, F(6, 376) = 28.25, p < .001$, partial $\eta^2 = .311$. The MANOVA was followed by ANOVAs for each subscale. As there was more than one comparison, a Bonferroni correction ($p < .025$) was applied. The ANOVAs revealed significant group differences for the Socialization/Nonverbal Communication domain, $F(3, 188) = 73.16, p > .001$, partial $\eta^2 = .539$, and the RRBIs domain, $F(3, 188) = 63.10, p > .001$, partial $\eta^2 = .502$. Games–Howell post-hoc tests were utilized because the assumption of homogeneity of variances was violated ($p < .001$).\(^{39}\)

In regard to the Socialization/Nonverbal Communication domain, all groups differed significantly from one another. The ASB group had the highest scores on this subscale, followed by the ASD + SEIZ group, then the ATYP + SEIZ group, with the ATYP group having the lowest scores (see Table 2). The ASD group’s total scores were significantly higher than the ATYP group ($p < .001$), the ATYP + SEIZ group ($p < .001$), and the ASD + SEIZ group ($p = .004$). The ATYP group had the lowest scores, which were significantly lower than all three other groups ($p < .001$). Lastly, the ASD + SEIZ group had significantly higher scores than the ATYP + SEIZ group ($p < .001$).

Regarding the RRBIs domain, the same trend was found, with the ASB group having the highest scores, followed by the ASD + SEIZ group, then the ATYP + SEIZ group, and finally the ATYP group (see Table 2). Again, the ASB group’s scores were significantly higher than the ASD + SEIZ ($p < .002$), the ATYP + SEIZ ($p < .001$), and the ATYP ($p < .001$) groups. The ATYP group had significantly lower scores than the ASD ($p < .001$) and the ASD + SEIZ ($p < .001$) groups; however, this group’s scores did not differ significantly from the ATYP + SEIZ group. The ASD + SEIZ and the ATYP + SEIZ groups were also significantly different ($p < .001$).

To further investigate the potential role of developmental delay, an ANOVA with DQ as the dependent variable was conducted. No outliers were identified; therefore, no transformations were applied to this data. The ANOVA revealed significant differences between groups $F(3, 186) = 13.98, p > .001$, partial $\eta^2 = .184$. The ASD + SEIZ group had the lowest DQ, followed by the ASB group, then ATYP + SEIZ group, with the ATYP group having the highest DQ. Levene’s test was not significant ($p = .945$); so, Tukey’s post-hoc tests were used and tests revealed that there were no significant differences between the ATYP + SEIZ, ASD, and ASD + SEIZ groups ($p > .05$). However, the ATYP group had significantly higher DQ than the other three groups; ATYP + SEIZ ($p = .001$), ASD ($p < .001$), and ASD + SEIZ ($p < .001$).

### Discussion

ASD symptomatology, as measured by the BISCUIT-Part 1, and developmental functioning, as measured by the BDI-2, were compared between groups of participants. Groups were determined by whether participants met criteria for ASD based on a review of records by a licensed clinical psychologist and had parent-reported comorbid seizures, met criteria for ASD without seizures, had atypical development, or had atypical development with comorbid seizures. Total DQ and total ASD symptom scores were examined, in addition to ASD symptoms in two separate domains: Socialization/Nonverbal Communication and Restricted/Repetitive Behaviors and Interests.

Consistent with previous research on intellectual ability, young children who qualified for an ASD diagnosis were found to have lower developmental functioning when they had a history of seizures than those who did not.\(^{5,30}\) Similarly, children without ASD but with atypical development also had

### Table 2. Autism symptom severity and developmental quotient comparison between groups.

<table>
<thead>
<tr>
<th>Domain</th>
<th>ATYP (M, SD)</th>
<th>ATYP + SEIZ (M, SD)</th>
<th>ASD (M, SD)</th>
<th>ASD + SEIZ (M, SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BISCUIT-Part 1:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASD symptom severity</td>
<td>18.54 (.92)</td>
<td>32.50 (18.75)</td>
<td>75.42 (20.54)</td>
<td>57.69 (21.76)</td>
</tr>
<tr>
<td>Socialization/Nonverbal</td>
<td>5.58 (7.99)</td>
<td>13.48 (11.32)</td>
<td>33.38 (9.36)</td>
<td>26.21 (12.03)</td>
</tr>
<tr>
<td>communication</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restricted/Repetitive</td>
<td>4.06 (5.02)</td>
<td>6.38 (6.18)</td>
<td>23.04 (10.25)</td>
<td>16.19 (9.74)</td>
</tr>
<tr>
<td>behaviors/interests</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BDI-Total DQ</td>
<td>78.02 (13.94)</td>
<td>67.15 (13.58)</td>
<td>65.42 (13.67)</td>
<td>60.17 (13.68)</td>
</tr>
</tbody>
</table>

Note: M: Mean; SD: standard deviation.

*Significantly different from ATYP, $p < .05$.

*Significantly different from ATYP + SEIZ, $p < .05$.

*Significantly different from ASD, $p < .05$.

*Significantly different from ASD + SEIZ, $p < .05$.

*The ATYP sample size for BDI-Total DQ was 46 rather than 48 due to missing data for two participants.
lower developmental functioning when they had a history of seizures. However, children without seizures had lower DQs when they met criteria for ASD as compared to those who did not. Interestingly, the differences between groups were only significant for the ATYP group and the other three groups. This indicates that both seizures and meeting criteria for ASD were significantly related to lower developmental functioning when compared to children without either condition; however, children with different combinations of these concerns did not significantly differ from one another.

These results showed some differences in autism symptomology between groups, both for total symptom severity and symptoms in the two diagnostic domains included in the DSM-5. Across total score on the BISCUIT as well as scores on the Socialization/Nonverbal Communication and the RRBIs domain, the ASD group scored the highest, indicating that these individuals had the most severe autism symptomology. The ASD + SEIZ groups had the second highest scores on all three variables, followed by the ATYP + SEIZ group, and finally the ATYP group. All four groups demonstrated significant differences from one another on both total scores and the Socialization/Nonverbal Communication domain. For the RRBIs domain, all groups were significantly different from one another with the exception of the ATYP and ATYP + SEIZ groups. This finding indicates that seizures in children with atypical development but without ASD may not be related to increased parent-reported symptoms of restricted, repetitive behaviors and interests.

Overall, for young children who met criteria for ASD, the presence of seizures was related to lower parental endorsement of symptoms related to autism, but the opposite trend was found for children without ASD. Specifically, children with atypical development but without ASD had higher scores of total autism symptoms and socialization difficulties when they had a history of seizures. These results may be partially due to the relationship between seizures and intellectual disability, as children with atypical development and seizures had significantly lower developmental functioning than atypically developing children without a history of seizures. This suggests that children without ASD but with seizures, and therefore potential ID or lower cognitive abilities, may display more symptoms commonly associated with ASD such as social difficulties than those without seizures who may have greater developmental functioning. This is consistent with evidence that cognitive abilities are important for social competence. The relationship between seizures and poorer social functioning is supported by the extant literature in the field. For example, a study by Camfield and Camfield indicated that adults who had epilepsy during childhood had high rates of social difficulties and that those with intellectual disability were more likely to have even greater deficits in social functioning. Further, the findings of a study by Matson and colleagues indicate that the presence of seizures in adults with intellectual disabilities was related to greater difficulties with social and adaptive skills. These results may suggest a connection between intellectual disability, seizures, and decreased social functioning.

Notably, children with atypical development did not differ significantly based on a history of seizures on the RRBIs symptoms, although all of the other groups demonstrated significant differences. This outcome suggests that seizures in children without ASD may not be related to increased prevalence and severity of restricted, repetitive behaviors or interests. Although the literature on the relationship between seizures and RRBIs is limited, these results are consistent with previous findings regarding seizures in mice. Lugo and colleagues induced seizures in mice early in their development and found that seizures early in life were related to social, learning, and memory difficulties but were not related to repetitive behaviors.

Children with only ASD had higher scores on total autism symptoms, as well as symptoms across both the socialization and RRBIs domains than children with ASD and comorbid seizures. This is the opposite trend of that found in children with atypical development. Although the ASD + SEIZ group had lower average developmental functioning than the ASD only group, this disparity was not significant. It is therefore unlikely that developmental functioning across these groups accounts for the discrepancies in ASD symptoms, as was suggested for the atypically developing groups. These findings contradict some previous research, such as a study by Smith and Matson, which indicated that adults with comorbid ASD and epilepsy had more impaired social skills than those with only ASD, epilepsy, or intellectual disability. A possible explanation for this discrepancy is the young age of the participants in the current study compared to the adults in Smith and Matson’s study. The potential influence of age is substantiated by a study including younger participants (i.e., 7–17 years of age), which indicated that children with ASD only were more likely to demonstrate unusual fascinations with objects and limited eye contact than the ASD and epilepsy group. However, the ASD and epilepsy group also showed higher rates of other RRBs related to ASD, indicating that there may be some variability in the expression of autism symptoms across these groups. Due to the discrepant findings in the field across samples of different ages and intellectual functioning, further investigation of the relationship between these comorbidities and ASD symptoms is warranted.

Another consideration is parent perception of their child’s behavior, particularly in relation to a medical condition. A previous study utilizing a sample of children enrolled in the EarlySteps program indicated that parents were more likely to refuse the autism screener when the child had a previous diagnosis of certain medical or genetic conditions. This may suggest that parents are less likely to have concerns related to ASD when their child already has a diagnosed medical condition. Cuccaro and colleagues investigated potential phenotypic expression of autism symptoms when seizures were also present, and they considered the potential difficulties in differentiating odd motor movements that may be associated with seizures and/or ASD. These authors noted that “in some instances, behaviors that are part of ASD … may be identified as seizure specific events. On the other hand, subtle automatisms, stereotypies, or prodromal events that are specific to seizures may be classified as repetitive or sensory behaviors” (p. 1628). It is therefore possible that parents may attribute some of the autism symptoms investigated in the current study to the child’s seizures or broader developmental delays.
The age of the children included in this study is of particular importance when interpreting these results. Researchers have found that seizures often do not develop until individuals are older, such as late childhood or even adolescence. The onset of seizures early in life may be associated with greater intellectual impairment. Relatively, seizures may also increase the risk for physical difficulties such as motor concerns. Overall, the literature indicates that due to the young age of the participants (<36 months), the sample utilized in this study may represent children with more substantial general developmental delays given the early onset of seizures or seizure disorders, which may at least partially account for some of the trends found in this study. Tuchman noted that children whose seizures begin prior to age 3 are at increased for ASD, and therefore should be monitored to aid in early diagnosis and access to comprehensive treatment.

Given the young age of the participants and the likelihood of communication delays, it is probable that the seizures experienced by participants in this study were types with more obvious features, such as the motor movements associated with tonic–clonic seizures rather than subtler types such as absence seizures, as the latter may be harder to recognize in young children. Although information on the type of seizure was not available through parent report for the majority of the sample, the category of seizure activity may be related to these results. Additionally, it is possible that seizures may not have yet been identified in some of the children in this sample, due to difficulties with identification in such young children.

Due to the importance of early intervention for both ASD and seizures, early identification of these conditions is essential for improving individuals’ outcomes. Children with comorbid ASD and seizures in this study had somewhat lower developmental functioning than those with only one condition, which indicates that these children may need more substantial supports, particularly early in life. Identification of comorbidities is of particular importance since there is evidence that symptoms of ASD (e.g., staring spells, lack of responsiveness to name or other environmental stimuli) may obscure identification of seizures. El Achkar and Spence recommend that providers demonstrate proficiency in the identification and differentiation of symptoms of ASD and seizures. Despite the lack of consensus across providers concerning screening for seizures, the high prevalence of seizures and epilepsy in this population and the evidence for a relationship between abnormal neurological activity and symptomology provided in this study highlights the need for particular consideration of comorbid epilepsy in children with ASD. Relatively, Tuchman and colleagues suggested that early diagnosis of seizures may also aid in the early identification of children at-risk for ASD. Timely treatment of seizures, such as medication or lifestyle changes, may have positive effects on outcomes of children with ASD; however, some researchers caution that clinicians should consider the potential adverse side effects of certain medications when constructing a treatment plan for children with ASD. Shubrata and colleagues emphasize that follow-up and continuous monitoring of seizures is necessary throughout development.

One study reported an interesting finding that autism symptoms improved in 8% of participants in a sample of individuals with ASD and epilepsy after epilepsy treatment. However, the majority of participants did not experience improvements in symptoms. A review by Robinson also indicated that there is some evidence of positive effects of anticonvulsant medications on behavioral concerns (e.g., aggression, emotional liability, self-injurious behavior). However, Robinson also noted that some individuals experience negative side effects, and suggest that physicians consider all relevant individual characteristics (e.g., age of onset, types of diagnoses, intellectual functioning) when prescribing medication. Tuchman further cautioned that the evidence that anticonvulsants may be related to positive outcomes in children with ASD is very limited and therefore should not be used to make recommendations.

The results of this study also support previous findings that females may be at increased risk for epilepsy within the ASD population. While ASD is currently considered to be four to five times more prevalent in males than females, the current study found that of the 48 participants who met DSM-5 criteria ASD and had comorbid seizures, 28 were male and 20 were female. Although this was not consistent with previous findings that more females than males with ASD may experience seizures, this sample indicated that the presence of seizure did seem to close the gap in prevalence between males and females. As the samples were age and gender matched, gender was not explicitly explored as a variable in the current study; however, these results encourage future research on the role of gender in atypical neurological activity in individuals who meet DSM-5 criteria for ASD.

The present study has several limitations. For example, as the data included in this study were obtained from an early intervention database, the majority of participants in the sample were children with a developmental delay or medical condition. Therefore, it may not be possible to generalize these findings to comparisons of children with ASD and typically developing children. However, the comparison with children with atypical development has some advantages, such as allowing the researchers to consider the results within the context of children with potential developmental delays. Further, the demographic form from which information regarding the child’s history of seizures was obtained was completed based on caregiver report rather than medical records, which limits the amount of information available on these seizures (e.g., type, frequency, duration). This demographic form also did not include detailed demographic information, such as socioeconomic factors, which are important to consider in future studies. While some researchers have investigated different types of seizures, further exploration into different categories may help to further explain the relationship between ASD and atypical neurological activity. Further, as seizures in young children are often associated with behavioral or cognitive conditions, the possibility of differential diagnosis for children in the ASD + SEIZ group should be considered. While the specific type of seizure was typically not specified by the parent, the possibility of presence of febrile seizures due to fever without the presence of a seizure disorder should be acknowledged. Therefore, these
findings should be considered preliminary, and replication of the current findings in a sample of children that requires official medical documentation of both diagnoses is warranted. Another consideration is that autism symptomology was based on a parent-report measure, the BISCUIT-Part 1. The use of observational measures such Childhood Autism Rating Scales-2 (CARS-2<sup>35</sup>) or Autism Diagnostic Observation Schedule-2 (ADOS-2<sup>55</sup>) may yield more objective estimates autism symptomology and should be considered for future research.

Preliminary results presented in this study suggest that parents may report lower levels of autism symptoms in children who meet criteria for ASD and have comorbid seizures than those without a history of seizures. However, the opposite trend was found when comparing children with atypical development but without ASD, as parents reported more autism symptoms when the child had previously experienced seizures. Further exploration of how seizures, particularly those that emerge early in life, are related to development and autism symptom expression is warranted.

**Declaration of Interest**
Deann Matson, Dr. Johnny Matson’s wife, is the sole owner of the Baby and Infant Screen for Children with Autism Traits (BISCUIT) and sells the scale.

**References**