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# Having Siblings is Associated with Better Social Functioning in Autism Spectrum Disorder

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**Abstract**
Sibling relationships play a unique developmental role, especially in emotional and social domains. In autism spectrum disorder (ASD), social-communication skills are often impaired in comparison to typical development. Therefore, studying siblings' effects on social skills of the child with ASD is important. This retrospective study examined how autism severity and functioning were affected by having older and younger sibling/s, the sex of the index child and of the sibling, and the number of siblings. The study population included 150 participants with ASD (mean age = 4:0 ± 1:6), divided into three equal groups (no sibling, older and younger siblings), matched for cognitive level. The evaluation included neurological and standardized behavioral, cognitive, and functional assessments. Children with ASD with older siblings showed less severe social interaction deficits and better social adaptive skills than only children. No significant differences in autism severity and adaptive functioning were noted between the group with younger siblings and the other groups. The more older siblings the affected child had, the better their social functioning. The sex of the participants with ASD and that of the sibling were not associated with social functioning. Social interaction deficits, the presence of older or younger siblings for children with ASD, and higher cognitive ability contributed significantly to the explained variance (48.9%) in social adaptive skills. These findings emphasize that older siblings positively influence the social skills of their younger sibling with ASD. The effect of typically developing younger siblings was modest and seen only in children with ASD and better cognition.

**Keywords** Autism spectrum disorder · Older sibling · Younger sibling · Adaptive skills · Autism severity

## Introduction

Autism spectrum disorder (ASD) is a lifelong neurodevelopmental disorder characterized by impaired reciprocal social communication and a pattern of restricted, often non-adaptive repetitive behaviors, interests and activities (APA 2013). As a spectrum disorder, the severity of ASD can vary considerably between individuals, impacting cognitive development, as well as social-communication, emotional, and adaptive behaviors (Zachor and Ben-Itzchak 2016). The social difficulties which are prevalent in children with ASD limit their opportunities to interact with peers. As such, family members play a critical role in the child's life, simply by being the most available people with whom the child can communicate (El-Ghoroury and Romanczyk 1999). In the general population, studies have found that sibling relationships play an important and unique role in typical development. The quantity and frequency of the interactions, stability and accessibility of the relationships between siblings, and the shared experiences and roles each sibling takes on all provide ample opportunity for children to develop emotional and social skills (Buist et al. 2013; Cicirelli 1982) and social understanding (Bowlby 1973; Bretherton 1985; Buist et al. 2013). The presence of an older sibling has been found to play a role in the development of the younger sibling's cognitive abilities, such as academic skills (Dai and Heckman 2013), language skills (Prime et al. 2014) and the development of theory of mind (ToM) (McAlister and Peterson 2013; Wright and Mahfoud 2012).

In the population with developmental disabilities, most studies which examined sibling relationships among children with ASD or other developmental difficulties focused on the

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impact on the typically developing (TD) sibling (Brewton et al. 2012; O'Brien et al. 2011). Examination of the impact of TD siblings on different developmental domains in children with ASD has been fairly limited. In regard to social functioning, it was found that during playtime, children with ASD initiated more interactions with their TD siblings than with their parents (El-Ghoroury and Romanczyk 1999; Knott, Lewist & Williams 1995). Employing TD siblings in play with children with ASD resulted in improved social playing skills of the siblings with ASD. These skills were generalized in different settings (Bass and Mulick 2007; Belchic and Harris 1994; Tsao 2004). Other improved abilities included better overall imitation skills (Walton and Ingersoll 2012) and social-communicative behaviors (Banda 2015). A previous study examined for the first time the relationship between having at least one older TD sibling and ASD symptom severity of the affected sibling (Ben-Itzchak et al. 2016). The study compared children without siblings to children with at least one older sibling, aged 1:6–5:0 years, who were matched for age and cognition (DQ/IQ). The study found that children with ASD who had an older sibling showed fewer social-communication deficits based on standardized test scores. Regression models also revealed that having older sibling/s was associated with less severe social-communication impairments. A few studies that have looked at the influence of the sibling's birth order on ToM development in children with ASD reported conflicting results. One study found that the performance of ToM tasks in children with ASD that had at least one older sibling in their age range did not significantly differ from TD children. However, children with ASD without an older sibling and those with a younger sibling performed worse on ToM tasks compared to TD children (Matthews et al. 2013; Matthews and Goldberg 2016). In contrast, O'Brien et al. (2011) found that children with ASD who had at least one older sibling performed worse on ToM tasks as compared to children who had at least one younger sibling. Several studies that looked at sibling relationships found that both TD children and children with ASD prefer interaction with their siblings that positively affect their social development (Jones and Carr 2004; Knott et al. 2007; McGee et al. (1997). Studies on the effect of sibling-mediated intervention found improvements in several social skills, such as joint engagement, imitation, and identifying social cues and social responses (Castorina and Negri 2011; Ferraioli et al. 2012; Oppenheim-Leaf et al. 2012; Tsao and Odom 2006; Walton and Ingersoll 2012).

Regarding the sex of TD siblings, one study did not find an association between the sex of the TD sibling and the quality of the relationship with the sibling with ASD (Rivers and Stoneman 2003) while another study found a sex effect, with female siblings showing more positive behaviors such as empathy and involvement with the TD sibling (Anderson and Rice 1992). To summarize, it is known that siblings provide a unique and important relationship, through which children develop social and emotional skills (Buist et al. 2013; Cicirelli 1982). However, until now, very few studies have examined the influence of the presence of siblings on the social abilities and symptom severity in children with ASD. There is only limited research on the influence of the sex of the child with ASD, and the sex of the sibling, and no research on the impact of the number of siblings on the social skills of a child with ASD.

The current study has three aims. First, to examine the effect of having older or younger sibling/s on autism severity and functioning of the child with ASD. Second, to examine the effects of the sex of the index child and that of the closest sibling in age (younger or older), along with the number of siblings, on autism severity and functioning. The choice to examine the closest sibling in age to the index child with ASD was based on the assumption that during childhood, most of the meaningful interactions are between siblings who are closer in age. Third, to explore the contribution of several of the index child's characteristics and siblings' presence to the variance in the social adaptive skills and social deficits of the child with ASD.

The study hypothesized that the three research groups will differ in their autism severity and adaptive skills. The group with older TD siblings will show the least severe autism symptoms and better adaptive skills, followed by the group with younger TD siblings, and then the group of only children. Having female TD siblings in comparison to male siblings will be related to better clinical presentation in autism severity and adaptive skills using standardized tests, as will having more siblings. Having siblings will predict better outcome beyond the contribution of factors such as cognitive ability and level of autism severity.

## Methods

### Participants

Figure 1 presents the flow chart of the participant inclusion procedure.

The initial population included 1425 children diagnosed with ASD at a tertiary Autism Center, during the years 2005–2016. Of these children, 282 were selected according to the following criteria: ages 1:6–6:11 years, completion of all the evaluations to be described in the diagnostic procedure, and having no sibling/s, or only older sibling/s, or only younger sibling/s. In order to differentiate between the effects of having younger or older sibling/s, children who had both older and younger siblings were not included in the study. Including middle children with ASD would obscure the contribution of the sibling's birth order. Of this cohort, we excluded those who had a known genetic syndrome (e.g Fragile X, neurofibromatosis), significant sensory deficits (deafness, blindness)

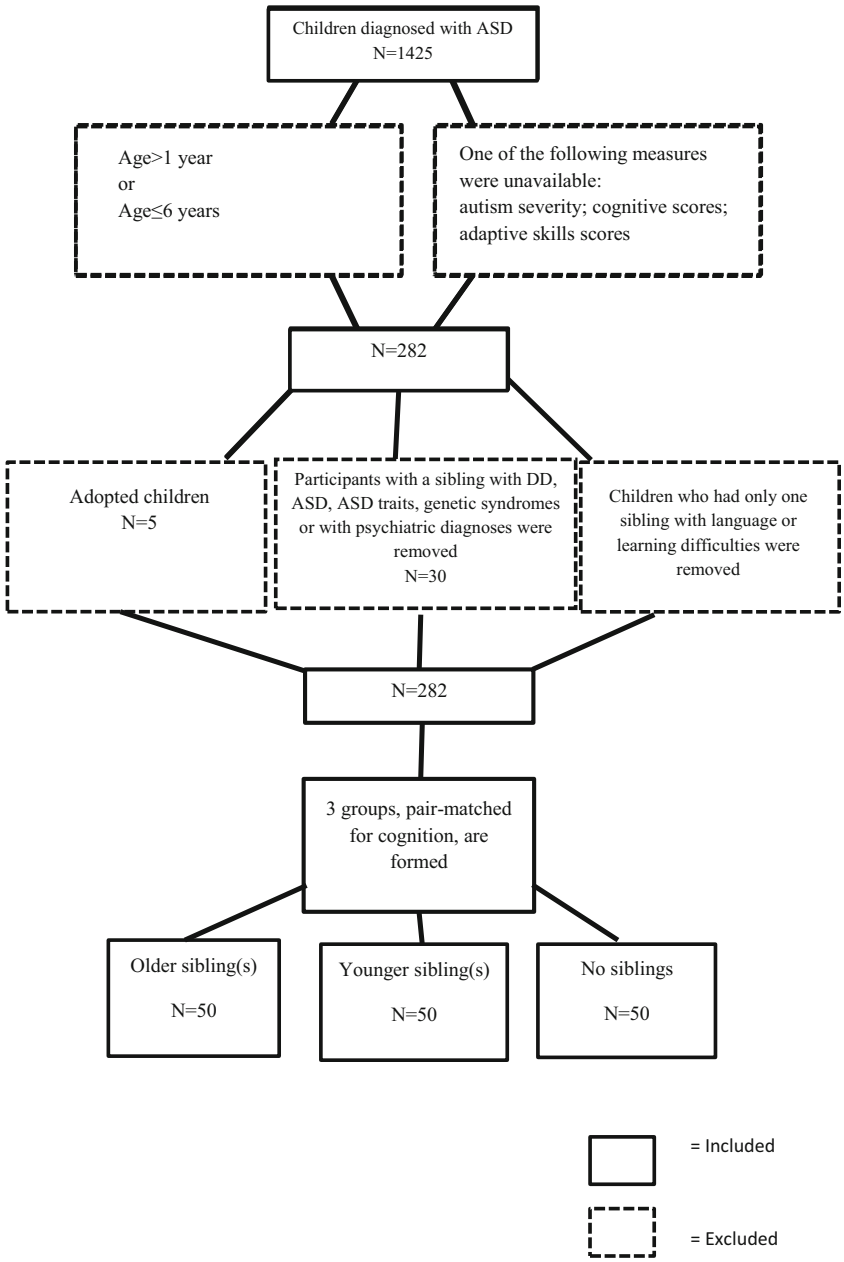


**Fig. 1** A chart flow showing the process of the participants' selection: inclusion and exclusion criteria

or were one of twins. Of the remaining population, 5 children were excluded because they were adopted and there was no information on their biological family. An additional 30 children were excluded because one of their siblings had a significant disability, including significant developmental delays, ASD, ASD traits, a genetic syndrome, or a chronic medical illness. These disabilities might affect inter-familial interactions and would not represent the typical sibling experience. For the same reason, ten other children with ASD were excluded from the study, since they had only one sibling (younger or older) and this sibling had minor disabilities (e.g. language or learning disabilities). When the child with ASD had more siblings than the one with minor disabilities, the child remained in the study. Of the remaining population ($n = 237$), three groups of 50 participants each (one with no siblings, one with older sibling/s, and one with younger sibling/s) were matched for their cognitive level. In cases where the child had more than one sibling, we used the data on the sibling that was closest in age to the participant (Tomeny et al. 2012).

The final study population included 150 participants aged between 1:6–6:9 years (M = 4:0, SD = 1:6), of whom 129 (86%) were males and 21 (14%) were females. Cognitive ability was in the DQ/IQ range of 49–124 scores (M = 86.83, SD = 16.75), and maternal education ranged between 12 and 23 years (M = 15.63, SD = 2.58). Of the 100 participants who had siblings, the closest sibling was a female for 52 of them and a male for 48.

To examine possible differences in the sex distribution of participants in the three groups and of the siblings' sex in the two sibling groups, two chi square analyses were performed.

As presented in Table 1, there was no significant difference in sex distribution between the groups. However, the group with older sibling/s had significantly more sisters than the group with younger sibling/s. To examine possible differences in age, cognitive ability, and maternal education, three one-way ANOVAs were performed. As presented in Table 2, no significant differences were noted in DQ/IQ scores and in maternal educational attainment. However, age differed significantly between the groups. Post-hoc Scheffe analyses revealed that the group with no siblings was the youngest, followed by the group with older sibling/s, while the group with younger sibling/s was the oldest. Significant differences were found between each pair of the groups ($p < 0.05$). Therefore, analyses with age as a covariate were performed.

## Measures

**Autism Diagnostic Interview-Revised** (*ADI–R*; Le Couteur et al. 2003): This is a semi-structured interview administered to parents, designed to diagnose ASD according to DSM-IV criteria. For assessment of autism severity, we used the ADI algorithm items with the entire score range (0–3) for the social and stereotyped behavior domains. Since not all the participants had the language requirement for coding the verbal sections (B2 and B3) of the ADI-R algorithm, in the communication domain, only items for non-verbal sections (B1 and B4) were used to avoid differences between verbal and non-verbal participants. Higher scores on the ADI reflect more severe autism symptoms. Internal consistency of the ADI-R using Cronbach's $\alpha$ is very high for the social domain (0.95) and lower for the communication domain (0.84) and for the RRB domain (0.69).

**Autism Diagnostic Observation Scales** (ADOS; Lord et al. 1999; ADOS 2-Lord et al. 2012): This is a semi-structured, interactive schedule designed to assess social and communicative functioning in individuals who may have ASD. Only one of the modules is administered, depending on the examinee's age and/or expressive language. The ADOS total algorithm score was used for calculating the total severity score using the ADOS calibrated severity scales (CSS) (Gotham et al. 2009). The scores of each of the ADOS subdomains, social affect (SA) and restricted repetitive behavior (RRB) were used for the calculation of each sub-domain severity score using the new SA and RRB calibrated severity scales (CSS) (Hus et al. 2014). Higher scores on the ADOS reflect more severe autism symptoms. Internal consistency is high for social affect ($\alpha = 0.91–0.94$) for all modules and lower for RRB ($\alpha = 0.47–0.65$). In the current study, the first version of ADOS was administered to 61.3% of the population and the ADOS-2 version to 38.7%. Module 1 was used in 38.7%, Module 2 in 50.7%, and Module 3 in 10.6% of the participants.

**Vineland Adaptive Behavior Scales** (VABS; Sparrow et al. 1984, 2005): This is a standardized caregiver interview designed to assess adaptive behaviors in children from birth to 18 years of age. The VABS is organized into four sub-domains: Communication (i.e. 'listens to instructions'; 'names at least 10 objects'), Daily Living Skills (i.e. 'feeds self with spoon without spilling'; 'talks to familiar person on the telephone'), Socialization (i.e. 'shows desire to please others'; 'plays cooperatively with one or more children for up to five minutes'), and Motor Skills (i.e. 'runs smoothly without falling'; 'unwraps small objects'), each of which yields a standard score (mean of 100, SD of 15). In addition, the measure yields a total score, the Adaptive Behavior Composite (mean of 100, SD of 15). Higher scores on the VABS reflect better functioning. Reliability data include internal consistency (0.70–0.97), test–retest (0.70–0.90), and interrater (0.70–0.80) for the parent/caregiver interview forms.

## Procedure

All the children included in the cohort had been referred to a tertiary Autism Center at a major hospital for a comprehensive assessment of a possible ASD diagnosis. The participants underwent a variety of assessments, including neurological, behavioral, cognitive and functional. Assessments were conducted by a skilled interdisciplinary team, including pediatric neurologists, psychologists, speech and language pathologists and

**Table 1** Sex distribution of participants and siblings

| | | No siblings | | Older sibling/s | | Younger sibling/s | | $\chi^2$ | p |
|---|---|---|---|---|---|---|---|---|---|
| | | N | % | N | % | N | % | | |
| Sex | Males | 43 | 86.0 | 42 | 84.0 | 44 | 88.0 | 0.33 | 0.42 |
| | Females | 7 | 14.0 | 8 | 16.0 | 6 | 12.0 | | |
| Sibling's sex | Males | – | – | 20 | 40.0 | 32 | 64.0 | 5.77* | 0.02 |
| | Females | – | – | 30 | 60.0 | 18 | 36.0 | | |

*$p < 0.05$

**Table 2** Means and standard deviations (SD) of age, cognitive ability, and maternal education in the three defined groups

| | No siblings M(SD) | Older sibling/s M(SD) | Younger sibling/s M(SD) | F | p | $\eta^2$ |
|---|---|---|---|---|---|---|
| Age (months) | 37.62(16.03) | 46.60(17.87) | 58.44(15.20) | 20.25*** | 0.00 | 0.22 |
| Cognitive ability | 86.88(17.10) | 86.04(16.59) | 87.58(16.88) | 0.11 | 0.90 | 0.00 |
| Maternal education | 15.59(2.57) | 15.64(2.73) | 15.55(2.48) | 0.004 | 0.97 | 0.00 |

***$p < 0.001$

special education experts. Parents gave medical, developmental and familial histories and pediatric neurologists conducted comprehensive neurological examinations of all the children. Information such as the number of siblings, their ages, and their medical and developmental histories was also obtained.

The diagnostic process employed two standardized tests, the Autism Diagnostic Interview-Revised (ADI-R) (Le Couteur et al. 2003) and the Autism Diagnostic Observation Schedule (ADOS) (Lord et al. 1999), and used the criteria set by the DSM-IV (American Psychiatric Association 1994, 2000) or DSM 5 (American Psychiatric Association 2013) for autism/ASD. Since the population was diagnosed over a period of time, different editions of the DSM were employed based on the year of diagnosis. Reliability was established,, by all professionals involved in all the ASD diagnostic tools. Cognitive and developmental abilities (IQ/DQ) were assessed using The Mullen Scales of Early Learning (Mullen 1995), Bayley Scales of Infant Development (Bayley 1993), Wechsler Preschool and Primary Scale of Intelligence (Wechsler 1989, 2002, 2003) or Stanford-Binet Intelligence Scales (Thorndike et al. 1986), using standard scores. Each developmental assessment was chosen according to the child's age and language level. The Vineland Adaptive Behavior Scales (VABS) (Sparrow et al. 1984, 2005) was employed in order to assess adaptive skills. ADOS, ADI-R and DQ/IQ and VABS scores were available for the entire group.

As explained in the Participants' section, the three examined groups with ASD were selected from the population that fulfilled the inclusion criteria by matching each child with no siblings to two children with older or younger siblings. The matched three participants, one from each group, had cognitive ability scores (DQ/IQ) that did not differ more than 5 points(±) from each other.

This research was approved by the Institutional Review Board (IRB) of Assaf Harofeh Medical Center in Israel as required. Since it was a retrospective study based on information from the participants' charts, the IRB did not require parental consent.

## Data Analysis

In the first stage, we compared the three examined groups for several demographic and child characteristics variables. For sex and sibling's sex, chi square analyses were performed. For maternal education, age, and cognitive ability, three one-way ANOVAs were performed.

Next, we compared the three groups for autism severity, including ADOS scores (ADOS-SA-CSS and ADOS-RRB-CSS) and ADI-R scores (Social interaction, Non-verbal Communication, RRB) with two MANOVAs. An additional MANOVA was performed to compare adaptive skills between the groups using VABS scores in four subdomains (communication, daily living kills, socialization and motor skills). When the MANOVA yielded a significant effect, one way ANOVAs were applied to each of the examined variables in this analysis. In addition, post-hoc Scheffe analyses were performed to identify the origin of the significant differences. For the analyses that yielded a significant effect, one-way MANCOVAs were performed, controlling for age. To examine the possible effect of the child's sex on autism severity and adaptive skills, three 2X3 (male/female X no sibling/older sibling/younger sibling) MANOVAs were performed for each of the above measures. Similarly, three 2X3 MANOVA were performed for the sibling's sex. Next we used Pearson correlation analyses to examine the correlations between the VABS socialization scores and several variables, including, ADI-R scores in all domains (social interaction, non-verbal communication, RRB), cognitive ability scores and the number of siblings in the family.

Finally, to examine the relative contribution of having a sibling to the variance of social adaptive skills and to the severity of social deficits, two hierarchical regression analyses were performed. One model with VABS socialization scores as a dependent variable, and age, sex, cognitive ability, ADI-R scores, and having an older or younger sibling as independent variables. In addition, the interaction of having a sibling (separately for younger or older) with each of the other variables was entered into the model in step-wise form. The second model used ADI-R social interaction impairment scores as the dependent variable with the same independent variables used for the first model.

## Results

To examine the effect of having sibling/s, we first compared the three groups (no sibling/s, having older

sibling/s, having younger sibling/s) in autism severity and adaptive skills.

**Autism Severity** The MANOVA for ADI-R scores was significant [$F(6,292) = 2.88$, $p = 0.01$, $\eta^2 = 0.06$]. As presented in Table 3, the group effect was significant for social interaction and RRB scores. Post-hoc Scheffe tests revealed that for social interaction, the group with older siblings had lower scores than the group that had no siblings ($p < 0.05$). For the RRB scores, the differences between the groups were not significant. We also performed ANCOVAs to examine the difference between the groups on ADI-R scores with age as a covariate. The analysis for social interaction remained significant [$F(2,146) = 3.50$, $p = 0.03$, $\eta2 = 0.05$], however the ANCOVA for the RRB sub-domain did not remain significant [$F(2,146) = 1.14$, $p < 0.05$, $\eta2 = 0.01$]. The second measure for autism severity was the ADOS-CSS. However, the MANOVA for this measure was not significant [$F(4,294) = 0.65$, $p = 0.63$, $\eta2 = 0.01$].

**Adaptive Skills** The MANOVA for the VABS scores was significant [$F(8,290) = 2.25$, $p = 0.02$, $\eta2 = 0.06$]. As presented in Table 4, group effect was significant for the motor skills abilities and a trend toward statistical significance was noted for the socialization sub-domain. Post-hoc Scheffe tests indicated that the group with older sibling/s had better scores in the socialization sub-domain than the group with no sibling/s (statistical trend, $p = 0.08$). The group with younger sibling/s showed a trend towards statistical significance, as this group had lower adaptive motor skills scores in comparison to the group with older sibling/s ($p = 0.08$) and the group with no siblings ($p = 0.06$). To evaluate the possible effect of age on these results, two ANCOVAs were performed for the VABS socialization and motor skills sub-domains with age as a covariate. The group effect for the Socialization subdomain remained with a trend toward statistical significance [$F(2,146) = 2.94$, $p = 0.06$, $\eta^2 = 0.04$] while for the motor skills the group effect diminished [$F(2,146) = 1.88$, $p = 0.16$, $\eta2 = 0.02$].

Examining the effects of the sex of the participants with ASD did not reveal any significant effect [$F(3,142) = 0.47$, $p = 0.70$, $\eta2 = 0.01$] nor group X sex interaction [$F(6,286) = 1.31$, $p = 0.25$, $\eta2 = 0.03$] for the ADI-R scores and for the VABS scores [$F(4,141) = 0.61$, $p = 0.66$, $\eta2 = 0.02$; $F(8,284) = 0.85$, $p = 0.56$, $\eta2 = 0.02$ respectively]. Examining the effect of the sibling's sex did not yield any significant sex effect nor sex X group interaction for the ADI-R scores [$F(3,94) = 0.68$, $p = 0.56$, $\eta2 = 0.02$; $F(3,94) = 0.47$, $p = 0.71$, $\eta2 = 0.01$ respectively] and for the VABS scores [$F(4,93) = 0.68$, $p = 0.60$, $\eta2 = 0.03$; $F(4,93) = 0.54$, $p = 0.70$, $\eta2 = 0.02$ respectively].

Next we examined correlations between VABS socialization scores and several variables. VABS socialization scores correlated negatively and significantly with all ADI-R socialization ($r = -0.62$ $p < 0.001$), non-verbal communication ($r = -0.52$, $p < 0.001$), and RRB ($r = -0.24$, $p < 0.01$) sub-domain scores and positively and significantly with cognitive ability scores ($r = 0.28$, $p < 0.001$) as expected. In addition, we examined the correlations between the number of siblings and the ADI-R sub-domains and VABS scores. The number of siblings correlated negatively and significantly with the ADI-R social interaction scores ($r = -0.19$, $p < 0.05$), and positively and significantly with the VABS socialization scores ($r = 0.23$, $p = 0.01$) and with daily living skills scores ($r = 0.18$, $p < 0.05$). Examining each group separately revealed that only for the group with older siblings but not for the group with younger siblings did the correlation with ADI-R social interaction scores ($r = -0.24$ $p < 0.05$) and VABS socialization ($r = 0.28$, $p < 0.05$) remain significant.

The third aim of the study was to evaluate the relative contribution of having sibling/s to the explained variance of the child's social adaptive ability and of the severity in social deficits, beyond the child's characteristics and maternal education. For this purpose, a hierarchical linear regression analysis was performed. In the first regression model, VABS socialization scores served as the dependent variable. Independent variables included sex and age in the first step, cognitive ability in the second step, ADI-R sub-domain scores in the third step, and having an older sibling or a younger sibling in two different variables in the fourth step. Interactions of having older or younger sibling/s with all the other independent variables were entered in the fifth step in stepwise form.

As presented in Table 5, the total model explained 48.9% of the variance of social adaptive skills. Cognitive ability in the second step contributed 8.0% to the explained variance; the greater the cognitive ability, the greater the social ability. Autism severity as measured by ADI-R contributed an

**Table 3** Means and standard deviations (SD) of ADI-R sub-domain scores in the three groups

| | No siblings M(SD) | Older sibling/s M(SD) | Younger sibling/s M(SD) | F | p | η2 |
|---|---|---|---|---|---|---|
| Social interaction | 12.52(5.48) | 9.46(5.59) | 11.20(5.31) | 3.95* | 0.02 | 0.05 |
| NV Communication | 6.96(3.21) | 5.88(3.70) | 5.78(3.52) | 1.76 | 0.17 | 0.02 |
| RRB | 4.28(2.15) | 4.32(2.44) | 5.34(2.72) | 3.01* | 0.05 | 0.04 |

*$p < 0.05$

**Table 4** Means and standard deviations (SD) of VABS sub-domain scores in the three groups

| | No siblings M(SD) | Older sibling/s M(SD) | Younger sibling/s M(SD) | F | p | η2 |
|---|---|---|---|---|---|---|
| Communication | 88.10(11.31) | 87.52(12.10) | 85.40(14.06) | 0.64 | 0.53 | 0.01. |
| Daily living skills | 82.04(11.20) | 83.82(10.71) | 81.88(12.70) | 0.43 | 0.65 | 0.01 |
| Socialization | 76.48(8.17) | 81.20(10.98) | 77.20(12.05) | 2.92^ | 0.06 | 0.04 |
| Motor skills | 90.56(9.91) | 90.80(11.37) | 85.48(12.42) | 3.55* | 0.03 | 0.05 |

*$p \leq 0.05$

additional 35.0% to the model; however, only the ADI-R social interaction sub-domain scores interacted significantly and negatively with VABS socialization scores. Having older or younger sibling/s in the fourth step did not add significantly to the model beyond the other variables. However, the interaction of cognitive ability and having either a younger or older sibling/s added 4.0% to the explained variance of social adaptive ability. Both interactions were significant.

To explain the significant interaction in the regression analysis, Pearson correlations were performed between VABS socialization scores and cognitive scores in each group (no sibling, older sibling/s, younger sibling/s) separately. The correlation between cognitive ability scores and VABS socialization score for the groups with older sibling/s ($r = 0.48$, $p < 0.001$) and younger sibling/s ($r = 0.41$, $p = 0.003$) were significant. However, for the group with no sibling, this

**Table 5** Hierarchical regression model for the VABS socialization scores

| Step | Variable | B | SE | β | $R^2$ | $\Delta R^2$ |
|---|---|---|---|---|---|---|
| 1 | Age m. | 0.04 | 0.05 | 0.08 | 0.008 | 0.008 |
| | Sex | 1.88 | 2.54 | 0.06 | | |
| 2 | Age m. | 0.01 | 0.05 | 0.02 | 0.088** | 0.080*** |
| | Sex | 2.80 | 2.46 | 0.09 | | |
| | Cognitive ability | 0.18 | 0.05 | 0.29*** | | |
| 3 | Age m. | −0.03 | 0.04 | −0.06 | 0.443*** | 0.355*** |
| | Sex | 1.69 | 1.96 | 0.06 | | |
| | Cognitive ability | 0.11 | 0.04 | 0.17* | | |
| | ADI-R SI | −0.94 | 0.16 | −0.49*** | | |
| | ADI-R Communication | −0.41 | 0.27 | −0.14 | | |
| | ADI-R RRB | −0.36 | 0.29 | −0.08 | | |
| 4 | Age m. | −0.03 | 0.04 | −0.05 | 0.449*** | 0.006 |
| | Sex | 1.60 | 1.96 | 0.05 | | |
| | Cognitive ability | 0.11 | 0.04 | 0.18* | | |
| | ADI-R SI | −0.89 | 0.17 | −0.47*** | | |
| | ADI-R Communication | −0.44 | 0.27 | −0.14 | | |
| | ADI-R RRB | −0.35 | 0.29 | −0.08 | | |
| | Having older sib. | 1.86 | 1.71 | 0.08 | | |
| | Having younger sib | −0.01 | 1.86 | 0.00 | | |
| 5 | Age m. | −0.03 | 0.04 | −0.05 | 0.489*** | 0.040** |
| | Sex | 2.54 | 1.94 | 0.08 | | |
| | Cognitive ability | −0.06 | 0.07 | −0.10 | | |
| | ADI-R SI | −0.81 | 0.17 | −0.42*** | | |
| | ADI-R Communication | −0.50 | 0.26 | −0.16 | | |
| | ADI-R RRB | −0.36 | 0.28 | −0.08 | | |
| | Having older sib | 2.06 | 1.67 | 0.09 | | |
| | Having younger sib | −0.09 | 1.81 | 0.00 | | |
| | Having older sib X cognitive ability | 4.89 | 1.61 | 0.27** | | |
| | Having younger sib X cognitive ability | 4.18 | 1.62 | 0.22* | | |

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$

correlation was not significant ($r = -0.09$, $p > 0.05$). Comparisons between the correlations using Z Fisher analyses yielded a significant effect for the differences between the correlation in the group with no sibling/s and the groups with older sibling/s ($Z = 2.95$, $p = 0.002$) and younger sibling/s ($Z = 2.53$, $p = 0.006$). No significant difference was noted between the correlations of the groups with older and younger sibling/s ($Z = 0.33$, $p > 0.05$).

The second regression model where ADI-R social interaction impairment served as the dependent variable explained 12.4% of the variance in total. Only having an older sibling ($\beta = -0.20$, $p < 0.01$) and ADOS-SA-CSS scores ($\beta = 0.18$ $p < 0.01$) added significantly to the explained variance (4.4%, 2.9% respectively).

## Discussion

The study examined the effect of the presence of siblings in the family of children with ASD. The first aim examined the effect of younger/older siblings and no siblings on autism severity and adaptive functioning of the sibling with ASD. Overall the study points to the benefit of having older siblings on the social functioning of children with ASD. Furthermore, children with ASD who have older siblings presented with less severe autism symptoms in both the social and RRB domains. However, this positive effect on RRB diminished when controlling for age, suggesting that the age of the participants affected these symptoms. It is worth noting that there were no significant differences between the group with younger siblings and the other groups (older/no siblings) in autism severity and adaptive functioning. From these findings, one can conclude that older TD siblings can function as a role model for their younger sibling with ASD, take a lead in the relationship and enable participation in social interactions such as play and discourse. It is possible that younger TD siblings are less capable of this role because of age and place in the family.

Several studies have suggested factors that influence social development. In line with attachment theory, a loving, warm bond with a sibling was postulated to reinforce positive internalized working models of self and others (Bowlby 1973), leading to better social adjustment. In addition, during playtime, children with ASD initiated more interactions with their TD siblings than with their parents (El-Ghoroury and Romanczyk 1999; Knott, Lewist & Williams 1995) and improved their social playing skills, which were generalized to different settings (Bass and Mulick 2007; Belchic and Harris 1994; Tsao 2004). These improved social-communication skills may lead to better interpersonal relationships later in life, as described by Natsuaki et al. (2009).

The effect of having older siblings on ASD symptom severity may also be related to parental factors. Parenting children with ASD has been associated with high stress levels (Davis and Carter 2008). It has been previously suggested that having a larger family may actively reduce the stress experienced by parents of children with ASD (Akerly 1984). More experienced parents with an older TD child acquire parenting skills that help with raising a child with ASD. Moreover, parents who raise older TD sibling/s may be less anxious in their parenting style. Both experienced and less stressful parenting styles might offer explanations for the reduced ASD severity in children with older sibling/s.

In the TD literature on sibling relationships, the dynamics between siblings and siblings' birth order were associated with personality development (McHale, Updegraff & Whitman 2012). Studies found that older siblings exhibit more social behaviors towards their younger siblings, such as collaboration, help, encouragement and praise of their younger sibling (Pepler et al. 1981; Lops 2015). These observations support the current study's findings on the impact of older TD siblings on the social development of the sibling with ASD in contrast to the lack of effect of the younger TD siblings.

For the second aim of the study we examined the impact of the sex of the participants with ASD, the sex of the closest sibling in age, and the number of siblings on autism severity and adaptive functioning. Based on parental reports, we found that a greater numbers of older siblings correlated with less impaired social interactions and better adaptive socialization skills on the part of the affected child. It is assumed that having more older siblings provides more opportunities for imitation and interaction. In addition, more than one older sibling enables group interactions, one of the most difficult social skills to acquire in ASD (Anderson et al. 2004; Morrier and Ziegler 2018). The sex of the participants with ASD and the sex of the closest in age sibling were not associated with autism severity, nor with adaptive functioning. Looking for variables that might affect adaptive socialization skills, a regression model was used which predicted about 50% of the explained variance in adaptive socialization skills. The significant contributing factors were parent-reported social interaction deficits, and the presence of older or younger siblings only for children with ASD and higher cognitive ability. This examination revealed a novel and interesting finding that the presence of younger siblings, in addition to the effect of having older siblings, is associated with better social functioning but only for children with ASD and high cognitive ability. It is possible that children with ASD and cognitive ability within the normal range benefit from interactions with their siblings regardless of whether they are older or younger. When examining variables that affect parental description of social interaction impairments during the structured interview, it was again shown that the presence of an older sibling was correlated with less severe social impairments. Overall, having an older sibling seems to positively affect different aspects of socialization in children with ASD.

Although it is well accepted from previous findings in typical development that siblings usually positively affect the social-emotional growth of their siblings, there are few studies that have examined the impact of having TD siblings on the social functioning and severity of ASD symptoms of the sibling with ASD. Several studies reported a positive effect of TD siblings during playtime (El-Ghoroury and Romanczyk 1999; Knott, Lewist & Williams 1995) and intervention sessions that involved siblings (Bass and Mulick 2007; Belchic and Harris 1994; Tsao 2004; Walton and Ingersoll 2012; Banda 2015). Sibling birth order was investigated in relation to ToM development in children with ASD and reported conflicting results (O'Brien et al. 2011; Matthews et al. 2013; Matthews and Goldberg 2016). A previous study reported for the first time that children with ASD who had an older sibling showed fewer social-communication deficits based on standardized tests scores (Ben-Itzhak et al. 2016). The current study expanded the examination of siblings' effect to include children with ASD with younger siblings and added demographic variables (sex, number of siblings) in addition to the participants' characteristics. The current study supported previous research findings that having an older TD sibling was associated with less impaired social deficits and better social functioning. The current study added that having a younger TD sibling was associated with better social functioning only in children with ASD and higher cognitive ability. In addition, the number of older siblings was associated with better overall social functioning. It is possible that the greater number of siblings a child has, the more opportunities he or she has for social modeling and play interactions. The sex of the child with ASD and that of the TD siblings was not associated with the participants' functioning.

These findings are in accordance with previous research that did not find an association between the sex of the TD sibling and the quality of the relationship with the sibling with ASD (Rivers and Stoneman 2003) or with Down syndrome (Pollard et al. 2013). Other studies found a sex effect, with female siblings showing more positive behaviors such as empathy and involvement with the TD sibling (Anderson and Rice 1992) and with a sibling with a disability (Lobato et al. 1991). Similarly, TD female siblings participated more in interactive activities with their adult sibling with ASD relative to male siblings (Orsmond et al. 2009). In the current study, only the effect of the sex of the closest TD sibling was examined. The sex of the other siblings was not assessed. In order to assess the impact of the sibling's sex, it is necessary to design a study that isolates the sex factor (e.g. only one sibling with a defined sex).

In a previous study that compared a group with no siblings to a group with older sibling/s, it was found that children with ASD with an older sibling showed less severe social deficits (ADOS SA-CSS) as assessed by the clinicians using the ADOS. This finding was not replicated in the current study. The main difference between the populations of the two studies was the age range of the participants. In the previous study, the mean age of the participants was $2{:}6 \pm 0{:}9$ years, while in the current study the mean age was $4{:}0 \pm 1{:}6$ years. In the current study, a group with younger sibling/s was added to the groups with no siblings and with older sibling/s; therefore, it was necessary to broaden the age range of the participants. It could be that in the current study, more children were given ADOS module 2 or 3, while in the previous study more children were administered ADOS module 1. This may have led to the difference in our current findings in comparison with the previous study's results. The age effect on the association between having a sibling and autism severity as measured by the ADOS should be investigated in future studies. To summarize, the current study emphasized previous findings that having older siblings has a positive impact on the social skills of the younger sibling with ASD. The study illuminated the fact that for children with ASD and better cognition (DQ/IQ), younger siblings might also affect social functioning.

The present study has several strengths. This is the first study to look at the effect of siblings comprehensively by examining several variables. The study looked at the effect of having younger and older sibling/s, their sex and the sex of the participant with ASD, and the number of siblings the participant had on autism severity and adaptive functioning. The study included a well-characterized population with ASD, carefully selected from a large ASD cohort using stringent criteria. For each participant with no sibling, a participant with only older sibling and a participant with only younger sibling/s were matched for cognitive ability to prevent any influence of the possibly confounding factor of cognition on the results. Stringent criteria were also applied for the characteristics of the sibling/s as participants, wherein siblings with major developmental disabilities and with language and learning disabilities were excluded. The study has several limitations: this was a retrospective chart review study and the three examined groups differed in their mean age which was the result of the nature of these groups, as was described above. In addition, the study did not directly assess the nature of the sibling interactions in the natural environment. To reduce the variability in the study population, the study was specifically designed to include a defined age-range and not to include middle children. In light of the study's findings, it will be interesting to examine the impact of having both younger and older siblings on the social-communication development of the middle child with ASD, and to examine older populations as well. In addition, the factor of the participants' age should be specifically addressed in future research on the effects of siblings in ASD. Further studies should evaluate the effect of the TD siblings on overall functioning in children with ASD, using direct observation of their interactions in a natural environment.

The study has several clinical applications. Firstly, in order to help parents learn how to create better interactions between their ASD and non-ASD children, we suggest involving siblings in intervention plans for children with ASD. Interventions that can promote socially meaningful skills with siblings and peers may include the Naturalistic Developmental Behavioral Intervention (Schreibman et al. 2015), encouraging more social interactions during unstructured activities (Morrier et al. 2009) and adding cooperative games (Bay-Hinitz et al. 1994). In teaching play strategies to TD siblings, we can leverage the favorable impact of their presence. In addition, parents who are raising both ASD and TD children should know that a TD sibling may contribute to the ASD sibling's development. It can be inferred from the results that children with ASD, particularly only children or those without older siblings, benefit greatly from inclusive preschools and classrooms with typical families and peer groups. These children are exposed to social situations and skills which they may otherwise lack. As was previously shown (McGee et al. 1999; Morrier and Ziegler 2018) and based on this study's findings, children with ASD may benefit from structured, cooperative group activities and a play recess curriculum in inclusive settings. In addition, programs that pair ASD children with TD older children one on one could provide this much-needed interaction.

## Compliance with Ethical Standards

**Conflict of Interest** Author Esther Ben-Itzchak declares that she has no conflict of interest. Author Noa Nachshon declares that he has no conflict of interest. Author Ditza A. Zachor declares that she has no conflict of interest.

**Ethical Approval** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This research was approved by the Institutional Review Board (IRB) of the medical center as required. Since it was a retrospective study based on information from the participants' charts, the IRB did not require parental consent.

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