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Abstract

Although children with autism spectrum disorder are frequently included in mainstream classrooms, it is not known how their social networks change compared to typically developing children and whether the factors predictive of this change may be unique. This study identified and compared predictors of social connectivity of children with and without autism spectrum disorder using a social network analysis. Participants included 182 children with autism spectrum disorder and 152 children without autism spectrum disorder, aged 5–12 years in 152 general education K-5 classrooms. General linear models were used to compare how age, classroom size, gender, baseline connectivity, diagnosis, and intelligence quotient predicted changes in social connectivity (closeness). Gender and classroom size had a unique interaction in predicting final social connectivity and the change in connectivity for children with autism spectrum disorder; boys who were placed in larger classrooms showed increased social network fragmentation. This increased fragmentation for boys when placed in larger classrooms was not seen in typically developing boys. These results have implications regarding placement, intervention objectives, and ongoing school support that aimed to increase the social success of children with autism spectrum disorder in public schools.

Keywords

autism, elementary schools, peer relationships, social networks

Elementary school classrooms in the United States are becoming more diverse, including children with and without disabilities. One of the fastest growing populations of children includes those with an autism spectrum disorder (ASD), which now affects 1 in 68 children and 1 in 42 boys (Centers for Disease Control and Prevention, 2014). Children with ASD are characterized by impairments in social communication and interaction as well as the presence of restricted interests and repetitive behaviors (American Psychiatric Association (APA), 2013). Although the level of severity varies, the social communication and interaction deficits often are pervasive, difficult to remediate, and nearly always affect peer relationships at school (Bauminger et al., 2010; Kasari et al., 2011). Research has shown that children with ASD experience more negative social connectivity, or distance from peers, as compared to their peers in school, that if left untreated worsen with age (Bauminger and Kasari, 2000; Chamberlain et al., 2007; Howlin et al., 2004; Kasari et al., 2011, 2012; Locke et al., 2013; Rotheram-Fuller et al., 2010). Many children with

ASD do not have a co-occurring intellectual disability; thus, placement in general education is increasingly common. However, the predictors associated with social connectivity in these settings are relatively unknown, yet are critically important to understand for the social inclusion of children with ASD in schools. Given the social challenges faced by children with ASD, it is important to understand why their social networks may fragment resulting in them becoming more distant from their peers, and whether social network fragmentation (caused when connections are lost between students) is similar to those seen in typically developing children.

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Social impairments present a major challenge for children with ASD placed in general education classrooms. Placement alone does little to improve their social outcomes, as challenges in social reciprocity and communication may impede social interactions, peer engagement, and friendship development and maintenance (Bauminger et al., 2010; Chamberlain et al., 2007; Ferraioli and Harris, 2011). Without appropriate support, children with ASD may experience more isolation, loneliness, and peer rejection, fewer reciprocal friendships, poorer friendship quality, less engagement with peers on the playground, and less social connectivity as compared to classmates (Bauminger and Kasari, 2000; Chamberlain et al., 2007; Kasari et al., 2011, 2012; Locke et al., 2013; Rotheram-Fuller et al., 2010). There also appears to be gender differences that affect both symptom presentation and social behavior in children with ASD (Dean et al., 2014; Werling and Geschwind, 2013). In particular, while male children with ASD form groups with other male peers, and females with females, some male children with ASD are more likely to have social network connections with female peers (Chamberlain et al., 2007). Peer relationships among males appear to be more “competitive” in nature, whereas female peers, on the other hand, tend to be more “helpful” and “socially mature” (Chamberlain et al., 2007). In addition, females with ASD may have more frequent as well as qualitatively different interactions with peers on the playground as compared to males (Dean et al., 2014), yet it is unclear as to whether gender may play a larger role in the overall social connectivity of the classroom. Despite an increasing number of studies of social connectivity of children with ASD in school settings, it is unclear what predicts how social networks change over time and whether these factors may be differentially modulated by gender.

Social network analysis may be used to predict the role of gender in the social connectivity of children with ASD and their peers. Social network analysis can be formalized using the mathematical techniques of graph theory, where “nodes” are viewed as individuals and “edges” are the connections among individuals, as shown in Figure 1. Graph theory is a mathematical approach to modeling networks which occur in real life; in graph theory, the relationships among nodes (individuals) often form regular and predictable patterns. Within school-aged children, social network analysis has found that the educational aspirations of students are dependent upon the racial and gender characteristics of their close friends (Hallinan and Williams, 1990), girls have more “exclusive” friendship triads than boys (Eder and Hallinan, 1978), and that a child’s attachment to school may depend on how she perceives her teachers feel about her (Hallinan, 2008). Social network analysis can also explain the dynamics seen in how behaviors spread, modeling the micromechanisms behind the continually evolving romantic and sexual networks of adolescents (Bearman et al., 2004), predicting the role of friendships in

suicide risk in adolescents (Bearman and Moody, 2004), and within adults the spread of loneliness (Cacioppo et al., 2009), happiness (Fowler and Christakis, 2008), and obesity (Christakis and Fowler, 2007). Within these social networks, “nodes” are continually added and edges are continually formed. Surprisingly, many similarities have been found in the architecture of these networks, forming a “scale-free” property where the connectivity behaves similarly within both large and small scales. This suggests that, in general, social networks have an intrinsic regularity across different populations.

Given the known differential effect of gender on ASD, we hypothesize that the changes within the social networks of children with ASD may be modulated by gender. The literature on graph theory shows predictability and regularity in the changes governing social networks; these social networks in elementary school may be similarly structured. Although children with ASD are members of a definitive social group, they are more often on the periphery of their classrooms’ social networks and less socially connected as compared to their classmates (Boutot and Bryant, 2005; Chamberlain et al., 2007; Kasari et al., 2011; Locke et al., 2013; Rotheram-Fuller et al., 2010). Given their tenuous positioning within their classroom social networks, we also believe it would be important to understand the interacting role of gender with other factors, such as age, classroom size, and intelligence quotient (IQ), variables that are commonly tested in models comparing differences between children with and without ASD as well as in tests of school-based interventions (Kasari et al., 2011, 2012).

The “closeness” measure (which we refer to here, more generally, as “connectivity”) is inversely proportional to the average number of steps required, via friendships, to travel from one child to all others and is used as the measure of social connectivity (Csardi and Nepusz, 2006). We measure the closeness to capture how connected a child is to all others in the classroom, both directly and indirectly; a student with high “closeness” has shorter paths to his or her peers compared to a child with low “closeness” (Freeman, 1979). In this study, social network analysis measures (i.e. closeness (inversely proportional to how many steps from one child to the rest of classroom) and degree (how many friends a child has) were used to predict the connectivity and the change in connectivity of children with ASD, along with age, IQ, classroom size, gender, and the number of children with ASD within that classroom, in order to characterize which children are likely to have social networks that become more connected over time and which children belong to social networks that may fragment or dissipate instead. These factors, and their interaction with gender, may predict the stability of social networks for children with ASD in elementary school, where basic demographic information may nominate in which classrooms children are most likely to succeed—possibly influencing classroom placement and important intervention decisions. Identifying

Figure 1. Each classroom forms a social network, where children are connected if they were nominated as a friend. Here, student “James” lost many direct and indirect friendships between Time 1 and Time 2, an example of social network fragmentation.

Table 1. Demographic information of average child with ASD within classroom, separated by the gender of the child(ren) with ASD.

Variable	Female (n = 35)	Mixed classrooms (n = 12)	Male (n = 106)
Age (years)	8.46	7.99	8.42
Class size (count)	21.11	22.17	22.52
IQ (points)	93.97	92	91.75
Degree T1	0.3	0.35	0.27
Connectivity T1	0.25 (0.15)	0.26 (0.13)	0.23 (0.19)
Connectivity T2	0.24 (0.16)	0.31 (0.13)	0.23 (0.17)
Connectivity change	0.01 (0.17)	-0.04 (0.1)	0 (0.19)

ASD: autism spectrum disorder; IQ: intelligence quotient.

these potential predictors may have important implications for classroom-based interventions in which the social structure is likely to worsen for students with ASD compared to children without ASD.

Method

Participants

Participants were drawn from a multi-site randomized-controlled treatment trial conducted in 152 classrooms in 59 public schools in 6 school districts across the United States that examined the effects of targeted interventions on the peer relationships and social functioning of elementary-age children with ASD (Autism Intervention Research–Behavioral (AIR-B) Network, 2008–2011). Social network data were gathered at two time points within the same school year. Baseline data collection was

performed after a minimum of 30 days into the school year and the second data collection point was completed within an 8- to 12-week window following baseline for each classroom. Children without ASD were randomly selected from the same classrooms as the children with ASD. Typically developing males were over-selected to make the gender breakdowns similar to the ASD sample, and all analyses additionally adjusted for gender as a main and an interaction effect.

Children with ASD were included if they were referred by school administrators and had a diagnosis of ASD from licensed professionals, had a documented non-verbal IQ of 65 or higher, and were included in a general education K-5 classroom for at least 51% of the school day, leading to a total of 182 children within 152 classrooms in 59 schools. Demographic and grade information are provided in Table 1 for available children with ASD. Overall, there were 4% of children in kindergarten, 15% in first grade, 22% in second

Table 2. Ethnicity and grade information of individual children with ASD.

	Kindergarten	First grade	Second grade	Third grade	Fourth grade	Fifth grade
African American	1	7	7	5	5	10
Caucasian	6	7	11	18	11	11
Hispanic	0	4	5	3	3	6
Asian	0	6	8	4	6	2
Other	0	0	1	4	0	1

ASD: autism spectrum disorder.

grade, 22% in third grade, 18% in fourth grade, and 19% in fifth grade. There were a total of 135 male students and 47 female students with ASD. The ethnic backgrounds of the children were as follows: 42% Caucasian, 23% African American, 17% Asian, 14% Latino, and 4% Other. Participants' age ranged between 5 and 12 years, with a mean age of 8.4 years (standard deviation (SD) = 1.52 years) and an average IQ of 92.31 (SD = 14.16), wherever available (11.6% of classrooms were in school districts which prohibited the use of intelligence tests), with additional demographic information provided in Table 2. The randomly selected children without ASD were 58.0% males and ranged 5–12 years, with a mean age of 8.4 years (SD = 1.5 years). IQ and ethnicity information were unavailable for non-ASD children.

Approximately 18.6% of the classrooms had multiple children with ASD, with males and females not differing in their likelihood of being assigned to this type of classroom ($p > 0.05$). Approximately one in three children with ASD was assigned to a classroom with another child with ASD. Classrooms with multiple children with ASD were larger, with approximately four more children than classrooms with only a single child with ASD. This difference was not statistically significant ($p > 0.05$). The average IQs of children placed in classrooms with multiple students with ASD were roughly 4.5 IQ points higher than those placed in a classroom with only children without ASD. Again, this difference was not statistically significant ($p > 0.05$). However, this may reflect anticipation within the classroom assignment process such that children with higher IQs may be more capable of handling a larger classroom. Although females with ASD were nearly two IQ points greater than males, this difference was not statistically significant ($p > 0.05$).

Materials

Friendship survey. Children were asked, "Are there kids in your class who like to hang out together? Who are they?" as a method of identifying specific children within each classroom social network group (see section "Coding social network centrality"). Children listed groups using free recall without prompting, class lists, or pictures. Children were reminded to include themselves in groups as

well as students of both genders. Individual assistance was provided to students who needed additional help reading and/or writing.

Coding social network centrality. Social network centrality refers to the prominence of each individual in the overall classroom social structure (Cairns and Cairns, 1994). Following Cairns and Cairns (1994), a series of social network analyses were conducted from the Friendship Survey to generate each student's level of involvement in his or her classroom's social network. The coding generated a co-occurrence matrix that captured children's nominated social network groupings, which was used for the analysis. This matrix captured a cognitive network where students report their perception of the network, rather than a behavioral network where students self-identify friendships. Because children with ASD may be more likely to misperceive friendships, this provides a more stable peer-derived estimate of the entire social network within that classroom.

Procedure

All school principals agreed to participate in the study as documented by a letter of collaboration provided to researchers. Recruitment materials were provided to the school administration to distribute to interested families. Families contacted the researchers if interested, and once informed consent was obtained, children were given a written assent and a comprehension quiz to ensure their understanding of the study prior to administration of the friendship survey. The friendships survey was administered twice during the school year, approximately 8–12 weeks apart.

Data analysis

We characterized which factors predicted children's social connectivity at baseline (the first administration of the friendship survey), change over time, and final connectivity 8–12 weeks later. Collectively, these models identify which covariates are most important in maximizing a child's chance of social success and how to predict which students are most likely to experience loss of connectivity or fragmentation during the school year.

Within each classroom, a child can be viewed as a vertex, v , of a weighted, undirected graph as shown in Figure 1. Friendship nominees can be viewed as edges connecting one child to another. We measured the social connectivity of the child with ASD using the “closeness coefficient,” where higher connectivity implies a student was more connected with the rest of the classroom. This was selected because it is a global measure of social strength which captures both the direct and indirect relationships of that student with the rest of the classroom. It is one of several similar correlated metrics which can be computed on social networks. The normalized connectivity was calculated as the inverse of how many steps were required to access every other vertex from a given vertex i , normalized by the total number of vertices (children), such that

$$\text{closeness}(v) = \frac{|V|-1}{\sum_{i \neq v} d(v,i)}$$

We calculated this using the package *igraph* within R (Csardi and Nepusz, 2006; R Core Development Team, 2012). We additionally measured the normalized degree of the child with ASD, where the degree is defined as the number of direct edges (connections) a student with ASD had, relative to the total number of students in the classroom. This additional local measure of social connectivity, compared to the global measure of closeness, helped to determine the impact of direct connections on the connectivity the child had with the rest of the classroom.

Classrooms containing students with ASD, and not individual students, were used as the unit of analysis since some classrooms had multiple children with ASD; for classrooms with multiple children with ASD (18.7%), the average measure (degree, connectivity, IQ, age) was used for continuous measurements, and factor variables (male, female, mixed) were used to summarize the gender of any children with ASD within that classroom. We additionally repeated these analyses using only classrooms with a single child with ASD (equivalent to using the child as the unit of analysis) to ensure these results were generalizable to both the average child with ASD within a classroom and the individual child with ASD.

We first modeled which factors affected the baseline social connections a child with ASD had within each classroom. Within a general linear model, we predicted the baseline connectivity using the age of the child with ASD, gender, IQ, classroom size, and the number of children with ASD per classroom. All second-order interaction effects were included, and an Akaike information criterion (AIC) stepwise model selection procedure was used to obtain the final model using the *step* function in R. Because the regression model was multivariate, these models estimated the effects of covariates on social connectivity while holding constant all else; for example, the effect of IQ on

the connectivity changes was assessed while holding constant the effects of gender. This ensures that the results for IQ are not due to, for example, an overrepresentation of males in the ASD group.

Next, we modeled the change in connectivity between Time 1 and Time 2 within each classroom, to identify which factors affected the social success of children with ASD (preconnectivity–postconnectivity). A positive change indicated a decrease in connectivity or that a student lost social connections during the school year. Within each classroom, we predicted the change in connectivity with a general linear model, using the age of the child with ASD, the gender, IQ, classroom size, initial connectivity and the initial degree of the child with ASD, and the number of children with ASD per classroom. All second-order interaction effects were included, and an AIC stepwise model selection procedure was used to obtain the final model using the *step* function in R.

Finally, we evaluated whether the factors governing the changes in social connectivity were similar in both children with and without ASD, by randomly selecting children without ASD for secondary analyses from the same set of classrooms as children with ASD. We evaluated whether the model from children with ASD, which best described the social connectivity change between two time points, was similarly realized in children without ASD. This was evaluated using two separate models. We first conducted a general linear model within children without ASD ($n=152$) using the same factors described above with the exception of IQ, which was unavailable. Second, we modeled the social connectivity changes among children without ASD who had lower baseline connectivity (below the median of all non-ASD children), to assess whether the changes seen in children with ASD may be related to the low baseline connectivity they begin with, rather than the disorder itself. These analyses together assess whether the factors predicting social connectivity changes are similar in children with and without ASD.

In addition, we validated whether the model fit within children with ASD replicated in a split-half control. We divided the data into two sets, using $n=68$ to train the model and $n=70$ for prediction. The multiple and the adjusted R^2 between predicted and actual values were used to assess model validity and predictive ability.

Results

Gender, age, classroom size, and IQ best predicted children’s connectivity at baseline as shown in Table 3. Higher IQ and larger classroom size predicted more connectivity as shown in Figure 2. For younger children with ASD, males were more strongly connected; being male was a social benefit for younger children, but this benefit decreased as a function of age. The negative interaction effect between class size and IQ predicted diminishing returns for children

Table 3. Baseline connectivity (closeness) of children with ASD.

Variable	Estimate	Std. error	t value	Pr(> t)
(Intercept)	-0.63	0.39	-1.64	0.10
Mixed gender	-0.13	0.33	-0.40	0.69
Male gender	0.37	0.22	1.69	0.09
Age	0.01	0.02	0.45	0.66
Class size	0.03	0.01	2.30	0.02*
IQ	0.01	0.00	2.61	0.01*
Mixed gender: age	0.02	0.04	0.46	0.65
Male gender: age	-0.04	0.03	-1.69	0.09
Class size: IQ	-0.01	0.00	-2.73	0.01**

ASD: autism spectrum disorder; IQ: intelligence quotient.

A positive connectivity suggests a net benefit to social connections for that variable, holding constant all else.

Significance level codes: *** 0.001, ** 0.01, * 0.05.

Figure 2. Overall, increasing IQ was associated with higher social connectivity at baseline. When broken down by gender, this effect was more prominent for female students.

with high-IQ scores or in a larger classroom. These effects were seen using both normalized and un-normalized connectivity measures, suggesting that they are not dependent upon classroom size.

The change in connectivity is influenced by the initial connectivity of the child, as shown in Table 4. Students who began the year with more connections lost a greater number of connections compared to students who began the year with fewer connections, an example of “regression to the mean.” Connectivity also was strongly affected by gender and classroom size where females performed better in larger classrooms, while males performed better in smaller classrooms. Using the parametric estimates from the regression model and solving for the number of students, 21 students per classroom was set as the break-even point, above which females perform better socially than males, holding constant the effects of age and IQ, as shown in Figure 3. This model predicted that females will be more

connected than males in classrooms with more than 21 students, while males will perform better than females in classrooms with 20 or fewer students, holding constant all other covariates (IQ, age, baseline connectivity). This finding did not change when excluding classrooms with more than 40 children, suggesting that it was not an artifact of influential observations (i.e. larger classrooms).

Males with ASD placed in larger classrooms experienced greater social connectivity losses than males placed in smaller classrooms. This was not seen in children without ASD (Table 5). In an additional model, we analyzed the change in social connectivity among children in the bottom half of social connectivity to assess whether the gender-dependent connectivity differences were an artifact of the low baseline connectivity of children with ASD (Table 6). Again, gender did not play a role in governing the social network connectivity changes of non-ASD children. The baseline, final, and change in connectivity by

Table 4. Change in connectivity over the school year for typically developing children.

Variable	Estimate	Std. error	t value	Pr(> t)
(Intercept)	0.08	0.12	0.65	0.52
Mixed gender	-0.43	0.21	-2.07	0.04*
Male gender	-0.28	0.13	-2.10	0.04*
Baseline connectivity	0.59	0.08	7.36	<0.001***
Class size	-0.01	0.01	-1.90	0.06
Mixed gender: class size	0.02	0.01	1.86	0.07
Male gender: class size	0.01	0.01	2.25	0.03*

A positive coefficient indicates the student became more distant to others during the school year.
Significance level codes: *** 0.001, ** 0.01, * 0.05.

Figure 3. A child's class size and gender better predicted their social connectivity at the end of the school year over age and IQ since gender and classroom size predicted the change. Males performed better in smaller classes, while females performed better in larger classes.

Table 5. Change in connectivity for 152 typically developing children.

Variable	Estimate	Std. error	t value	Pr(> t)
(Intercept)	-0.22	0.07	-3.20	0.00**
Male gender	0.02	0.08	0.31	0.76
Baseline closeness	0.69	0.07	9.86	<2e-16***
Class size	0.00	0.00	0.82	0.41
Male gender: class size	0.00	0.00	-0.28	0.78

Significance level codes: *** 0.001, ** 0.01, * 0.05.

Table 6. Change in connectivity for typically developing children with baseline connectivity below the median value.

Variable	Estimate	Std. error	t value	Pr(> t)
(Intercept)	-0.18	0.09	-2.11	0.04*
Male gender	0.01	0.10	0.11	0.91
Class size	0.34	0.26	1.28	0.21
Baseline connectivity	0.00	0.00	0.90	0.37
Male gender: class size	0.00	0.00	-0.11	0.91

Significance level codes: *** 0.001, ** 0.01, * 0.05.

Table 7. Summary of measures by diagnostic group.

Measure	ASD		Non-ASD	
	Mean	SD	Mean	SD
Baseline connectivity	0.24	0.18	0.27	0.17
Final connectivity	0.24	0.17	0.25	0.14
Change in connectivity	0.003	0.20	0.02	0.17

ASD: autism spectrum disorder; SD: standard deviation.

Higher connectivity values suggest a student is closer to other students in the classroom.

diagnosis are presented in Table 7. On the split-half validation, the predicted and actual connectivity changes for children with ASD had multiple $R^2=0.37$ and adjusted $R^2=0.36$.

Discussion

This study used graph theory to identify predictors of social network fragmentation and connectivity for children with and without ASD over 8–12 weeks. The results indicated that higher IQ and larger class size predicted more social network connectivity at baseline. In addition, connectivity predicted fragmentation; the closer the children were to other students, the more the social connections were lost over time. Female students tended to fare better in larger classrooms, whereas male students were socially more successful in smaller classrooms. Although IQ and age were important predictors of social connectivity at baseline, children's gender and classroom size were the most important factors in determining social network connectivity 8–12 weeks later.

Understanding the prognostic indicators of social connections for children with ASD in mainstream settings may provide direction to educators and parents in advocating for particular classrooms and for social interventions at school. Although these results are descriptive, classroom size may be a powerful factor to consider when deciding children's placement in inclusive school settings. Female children with ASD were more socially connected in classrooms with 21 students or more, whereas male children with ASD were more socially connected in classrooms that were smaller, with 20 students or fewer. These differential results support other findings on the social relationships of children with ASD at school, which suggests that gender differences do exist in the ways in which children socialize. Children with ASD tend to socialize with their same-sex classmates (Dean et al., 2014). Thus, one reason girls with ASD may be more socially resilient in larger classrooms is that they may have more peers to choose from—peers who may be more understanding of their social challenges that inhibit their ability to navigate the complexity and subtlety of female relationships (e.g. interpreting subtle nuances, being intimate, and conforming with

group interests; Dean et al., 2013, 2014). On the other hand, since male relationships place more emphasis on competitive play (Blatchford et al., 2003), which relies less on social ability and more on athletic ability, it is understandable that males did not show the same pattern as females with ASD. Social impairment is one of the core deficits of ASD, and ASD affects more males than females. Given the impact of classroom size observed here and the existing trends which show increasingly larger classroom sizes as early as elementary school, these data suggest that class size may be an important factor to consider in placing children with ASD in classrooms to maximize the likelihood of their social success. Further research on additional characteristics of the classrooms (e.g. dynamics) and schools (e.g. culture, climate) may potentially point to the ways in which classrooms are reconfigured and organized in schools to optimize social engagement.

Although classroom size increased the negative social change for males with ASD, this relationship was not seen in children without ASD when analyzing all children without ASD ($n=152$), nor when analyzing poorly connected children without ASD. This suggests that intervention and supports may be needed to sustain peer relationships over time for children with ASD. Providing ongoing support to children with ASD during unstructured social times such as recess may prevent fragmentation from occurring; however, additional research is needed to fully understand what needs to be done in public school settings to promote the social success of children with ASD.

Furthermore, since the goal of many school-based interventions is to improve the social relationships of children with ASD, these data may have important implications on selecting intervention objectives as well. Focusing on the quality versus quantity of relationships may be important for sustainment and continued peer connectivity. Children who had more connections at baseline had more fragmentation in their social networks as opposed to children who had fewer connections; in essence, these children had more to lose. Building strong and quality relationships with a few peers may be an important intervention objective to ensure continued social success and connectivity with peers. Future studies are needed to explore this issue. Finally, other factors that may influence social connectivity (e.g. autism severity and communication skills) were not available to be tested as predictors and warrant investigation in future studies.

This study suggests that children with ASD experience decreasing connectivity with classmates over the school year. Although this study employed novel analytical methods to predict fragmentation of children's social network connectivity over time, there were several limitations. Not all children in a class provided consent; our conclusions assume that consenting and non-consenting children were similar. Graph theory measures may be sensitive to the number of vertices (classroom size), which were guarded

against by (1) running models with both normalized and un-normalized measures of connectivity and (2) adjusting for classroom size within the model explicitly. There was variability in the IQs of students with ASD as well as the classroom size; these results were replicated when excluding larger classrooms (over 45 students) and higher IQ students (over 140) from the models, indicating that they were not driven by influential observations. We controlled for regression to the mean by including the baseline connectivity when measuring change; differential effects of classroom size and gender were seen after adjusting for the baseline connectivity levels. Because this analysis was performed using classrooms as the units of analysis instead of students, these recommendations may be quite general. We repeated these analyses using only classrooms with single children with ASD and found similar results. These replications suggest that our results are stable for different IQs, classroom sizes, and units of analysis (classrooms or individual students). The social network connectivity in children without ASD did not show an effect of gender or classroom size; the changes in connectivity in children without ASD were largely dependent upon their baseline connectivity. These findings were not due to the sampling differences with gender since gender was adjusted for as a primary covariate in both the ASD and non-ASD groups in the multivariate regression models. These findings also were not due to the differences in baseline connectivity seen between children with and without ASD since the lower-connected children without ASD also failed to show a gender interaction with classroom size. Finally, in addition to the factors studied here, other factors that may influence social connectivity (e.g. autism severity and communication skills) were not available to be tested as predictors and warrant investigation in future studies.

This study suggests that children with ASD experience decreasing connectivity with classmates over the school year. Boys with ASD were more socially connected to classmates than girls in early elementary school years, but this effect dissipates as a function of age. Classroom size affected boys and girls with ASD differently in terms of social connectivity to peers. Boys retained more connections to peers in classrooms of 20 children or fewer, while girls performed better than boys in classrooms of 21 or more. Future studies should examine these and other issues: timing and nature of social intervention delivery, social-related strengths and needs of students, autism severity, communication modes, classroom size and the placement of children with ASD considering gender differences, and whether all children's networks fragment over time and if so are there unique predictors for children with ASD as compared to their typically developing counterparts.

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