Social Network Structure in Autistic Individuals: A Systematic Review

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All authors declare they have no conflict of interest.

Abstract

Background: While many studies aim to address social communication differences between autistic and non-autistic individuals, little is known about the real-world impact on the quantity and quality of social relationships that develop across their lifespan. Social network analysis captures the size and connectedness of one's social network and offers insight into one's social connectivity with other people either within one (e.g., school, workplace) or multiple social settings.

Method: Following PRISMA guidelines, we searched across PubMed, PsycINFO and Web of Science to identify articles that examined how social network structure is measured amongst autistic individuals, and the characteristics of social network structure across the lifespan.

Results: After removing 308 duplicates from 4,177 identified studies, we screened titles and abstracts for 3,869 articles and full texts for 70 articles. 25 studies met eligibility and led to 4 additional relevant studies identified from reference lists, with a total of 29 studies included for narrative synthesis. Most studies were US-based (n = 19) and included children and young people (n = 21) recruited from local schools (n = 20). Many studies (n = 17) used the Friendship Survey to assess peer relationships within classroom settings, with social networks that reflect peer acceptance, rejection, and reciprocal friendships. Results indicate autistic children experience greater isolation with more peripheral status and lower peer acceptance compared to their neurotypical peers. Other social network mapping tools in adults captured both social network structure (for example, number of network members and their connections with each other), and some captured support provided by network members, with family members often cited as providing the most frequent and best quality support across a range of life domains.

Conclusion: There is limited knowledge about social network structure for autistic individuals beyond childhood in classroom settings. Social network analysis may provide a valuable snapshot into the types of social connections an autistic individual may have in one or more settings. However, we emphasise the need to work together with autistic individuals to understand how they perceive their social network structure to be meeting their social need.

Keywords: autism, social skills, peer relationships, social networks

Community Briefing

Why is this topic important?

Many interventions aim to improve social inclusion for autistic individuals in different social settings. However, there is a risk of imposing the neurotypical assumption that not only quality, but also number of social relationships may reduce isolation and improve availability of support to autistic individuals. Social network analysis is a methodology that can create personalised maps that show how an autistic individual is connected to other people within one or multiple social settings. Social network map can explore the most important relationships to an autistic individual, and spark conversations around how their social network can best meet their social and non-social needs.

What is the purpose of this article?

We want to explore how social networks are currently measured in autistic individuals across the lifespan, and key features of social connections across the lifespan.

What did the authors do?

We designed a search strategy that focused on autism and social network characteristics such as number of social network members involved and their connections with each other and identified relevant literature across three academic databases. We reviewed published studies to look at different ways of measuring social network characteristics in literature, and different features of social networks across autistic individuals' lifespan.

What did you find about this topic?

We found 29 studies that measured social network characteristics in autistic people. Most studies looked at social connections between autistic children and classmates in US school settings. Autistic children are more isolated and found on the edge of social groups in classrooms. Few looked at social network characteristics in adulthood and through life transitions. Social network sizes vary significantly depending on the measurement used. Autistic young adults perceive family to provide more frequent high quality support during transition to university. Autistic adults perceive family to provide more practical support, and partners to provide more emotional and social participation support.

What do the authors recommend?

We highlight that interpretation of social networks needs to be done collaboratively with the autistic individual to understand from their perspective: 1) how they are getting their social needs and goals met within their existing network, and 2) plan with the autistic person on what meaningful changes (if any) they may wish to see in their social network. We also highlight that future research can explore how different people seen as important by the autistic individual can provide insight into how the autistic individual is accepted by different people within their network.

How will these findings help autistic adults now or in the future?

We hope generating social network maps along with the autistic individual can help practitioners better understand and support autistic individuals to explore and consolidate their social connections in a way that is meaningful to them. We hope social network measures can become a more meaningful outcome measure that incorporates autistic individuals' perspectives and captures real-life changes in social relationships when evaluating interventions that aim to improve social inclusion for autistic individuals across the lifespan.

Social isolation and exclusion can have a detrimental impact on quality of life and mental health in autistic[1–4] and non-autistic individuals.[5] Navigating a social world and communicating with neurotypical individuals, autistic people may often experience negative social experiences that arise from the double empathy problem,[6,7] where social communication differences across neurotypes can create difficulties in reaching a shared understanding that facilitate social connections.[8] Many childhood interventions focus on social skills development and imply that social communication differences reside within autistic individuals, and not enough emphasis on the importance of environmental influence on addressing the double empathy problem.[8] The perceived pressure to appear "normal" and "fit in" with neurotypical peers in everyday social spaces may result in autistic individuals masking their autistic traits and social communication differences.[9–11] Prolonged masking is also associated with poorer mental health outcomes in autistic young people and adults.[12–14] Sinclair[8] highlights the importance of having shared autistic space where autistic people are in charge and can determine what their needs are and how best to meet them. However, the need to respect individual differences in autistic individuals' desire for social connection in such spaces is crucial for creating networks that suit each individual's needs.[8]

Social network analysis is an important methodology for capturing individual differences in the quantity and quality of social connections that is either available to or perceived to be meaningful by a person. Social network studies with non-autistic people have revealed the important role of size and density in creating interpersonal relationship, employment, and community participation.[15–17] Social network measurement (see a list of key terms and definitions for social network research in Table 1) usually focuses either on understanding all of the interpersonal relationships between all individuals in a defined space (sociomap), or by understanding the relationships between individuals that are significant to one individual (the reporter) across all walks of life (ecomap).[18] Sociomap can help understand any individual's social acceptance and rejection by a well-defined social group (e.g., in a school classroom setting) when combining multiple reporters' nominations within the same social circle.[19] Ecomaps can provide a better understanding of how individuals perceive the quality of their relationships with people across different social spheres, such as family, friends, colleagues, and other people who may not know each other directly.[20] Both types of network measurements offer valuable information to gather insight into how an individual interacts with one's social environment and provide tangible and quantifiable metrics to show the degree of social connectedness or social isolation experienced over time.

[INSERT TABLE 1]

Compared to structural components, how one draws on the function of their own social network tends to be more subjective and can change across the lifespan. For example, the Socioemotional Selectivity theory[21,22] suggests individuals' need and motivation for social relationships can change across the lifetime. During adolescence and young adulthood, individuals seek new information and opportunities through establishing new relationships, reflected by a large and loosely connected social network. In contrast, during older age and stable phases of one's life, individuals maintain smaller and well connected social networks to support emotional wellbeing.[21,22] A similar pattern is observed for autistic individuals. Frequency of socializing with friends and neighbours peak during adolescent and early adult years but decrease significantly during older age.[23] The smaller social network for older autistic individuals is likely due to a lack of social support[24] for developing friendship rather than a deliberate choice by autistic individuals. However, research in this area remains quite limited.

When evaluating individual differences in social network structure and function, it is particularly important to account for how life stage transitions may affect the quantity and quality of social relationships maintained by an individual at a given time. For example, young people going to university may be leaving home for the first time, and close friends who used to be the center of one's network may choose to go to a college in a different city. Using social network analysis can offer a visual representation of one's current state of social connections and offer scope for having more concrete and structured conversations with individuals to plan for upcoming life transitions. Planning for upcoming social network changes may encourage autistic individuals to create a social network that will meet their needs. This self-driven planning process of assessing the changes and needs and seeking out relevant support is key to successful transition experienced by all adolescents and young adults and their quality of life, including those on the spectrum.[25,26]

Capturing the diversity of social network structures reported by autistic individuals may also provide important information for normalising different ways of connecting with other people in one's social sphere and improve understanding of the association between quantity and quality of relationships from autistic individuals' perspectives. Given that no reviews to date have examined social network structures amongst autistic individuals, the current review aims to provide a comprehensive understanding of autistic individuals' social networks with two questions:

1. What measures have been used to assess the structural characteristics of social networks in autism?
2. What are the characteristics of social networks amongst autistic individuals?

Method

Search Strategy

This review followed the PRISMA 2020 Checklist[27] (see Supplementary Materials A). We conducted a search of all peer-reviewed journal articles across PsycINFO, Web of Science (WOS), and PubMed, and dissertation and thesis via ProQuest. Search terms included:

1) **Condition (in all fields):** (Autis* OR ASD OR ASC OR Asperger OR Pervasive Development*)
   AND
2) **Social Network (in all fields):** (social network*)
   AND
3) **Language:** English
   AND
4) **Subjects:** Humans

To increase the scope of the review, we adopted a lifespan perspective and did not set any parameters on age and did not set parameters for date of publication. We conducted the initial search in July 2021 and three subsequent searches in December 2021, June 2022, October 2023, and July 2024. We identified 5,428 articles (PsycINFO=1698, WOS=1693, PubMed=1937, Proquest=100) and screened reference lists of selected full texts for additional articles (see Figure 1 for PRISMA Flow Chart).

[INSERT FIGURE 1]

The search process included three stages. We first collated results in Excel before we removed duplicates and completed title and abstract screening. We excluded articles if they (1) had a title or abstract irrelevant to the purpose of the review, (2) were not in English, or (3) were not peer-reviewed (except for dissertation/thesis work). Next, we conducted a full-text review to include articles that met the inclusion criteria. We excluded non-journal articles, systematic review/meta-analyses, opinion and commentary articles, qualitative studies and case series. Finally, we did an ancestral search (i.e., search through full reference list) of the 25 articles found during the second search phase. This process identified four more articles which met the inclusion criteria. In total, 29 studies were included for narrative synthesis.

Inclusion and Exclusion Criteria

To determine inclusion criteria, we followed the Population, Intervention, Comparison, Outcome, and Study Design (PICO) guidelines.[28] We included published peer-reviewed articles and unpublished dissertation/thesis in English (published since 2000) up to July 2024. We excluded systematic reviews/meta-analyses, case series, opinion articles, non-English publications, articles that do not have a social network measure, and dissertations/theses which used data that have since been published as peer-reviewed articles that met full inclusion criteria (this was identified through looking at research group affiliations, study recruitment, and participant information).

Population. We included participants who have a clinical, educational, or self-diagnosis of autism, and autistic individuals who have co-occurring conditions if social network structure measures are delineated across comparison groups to allow clear identification of the impact of autism on social network structure per se.

Intervention. Intervention studies were included in the review if they met all other inclusion and exclusion criteria stated under Population, Comparison and Outcome.

Comparison. Studies may include a comparison group, such as non-autistic participants or participants with other disabilities to understand the differences in structure and function of social networks between autistic individuals and peers.

Outcome. Studies must include at least one social network structural measure as an outcome measure and define components of social network structure as variables listed in Table 1.

Quality Indicator Appraisal

To measure study quality, we used the quantitative scale of the QualSyst.[29] This quality indicator has been used previously to review autism literature.[30] For quality appraisal, we coded 14 dimensions of quality indicators assessing study objectives; study design, participants selection, random allocation (if applicable), outcome measure, sample size, analytic method, estimate of variance, controlling for confounding, reporting results, and conclusion. A final score was calculated based on the formula described by Kmet and colleagues[29].

Inter-rater Reliability and Coding

Inter-coder agreement for quality appraisal was calculated in all three phases of coding. Prior to coding, we trained all three coders by using randomly selected articles to reach 100% agreement on screening titles/abstracts, coding study variables and quality indicators. Training was completed via discussing any discrepancies in coding across the three coders to resolve disagreements. All three coders have extensive research experiences in the field of autism and intellectual disability. Following this procedure, we randomly selected 20% of the articles to be coded by all coders to calculate interrater reliability on study variables and quality indicators.

Data Extraction

Study variables included: (1) the name of the country where the participants were recruited, (2) sample size, (3) diagnosis information, (4) age, (5) IQ (if reported), and (6) gender identity or biological sex as reported by article. For social network measures, we coded network characteristics such as network centrality, size, density, and types of connection (e.g., family, peer, professional), relationship quality (acceptance, rejection, reciprocity, contact frequency, mode of contact, length of relationship), and perceived social support from social network members.

Results

Search Results

The PRISMA diagram (Figure 1)[27] summarises the literature search process. After removing duplicates, the first author completed title, abstract and full-text screening. We selected all 29 studies for quality assessment. For the 17 studies that used Friendship Survey as the social network measure, study quality ranged from 0.73 to 0.95. For the 12 studies that used alternative tools to capture social networks, study quality ranged from 0.5 to 0.94.

A second coder independently screened 20% of abstracts and full text articles to assess interobserver agreement on study variables and quality indicators. We calculated the percentage agreement scores by dividing the total number of agreements by the total number of agreements plus disagreements and multiplying the quotient by 100. Agreement is 78% (n = 27; Kappa coefficient = 0.71) for abstract screening and 82% (n = 27; Kappa coefficient = 0.92) for full text screenings, and 74% for quality appraisal variables across all 14 dimensions of quality indicators.

Study Characteristics

Tables 2 and 3 summarize the characteristics for the 29 included studies. A total of 1820 autistic individuals (n = 1219 male) took part in the studies, with most studies completed with children and young people under the age of 18 years old, and only eight studies with adults (number of participants = 650, mean age = 32.42 years). The majority of studies were US based (n = 19), with only four studies based in the UK,[31–34] two in Spain,[35,36] two in the Netherlands,[4,37] one in France[38] and one in China.[39] Most participants came from local schools (n = 20), with a few from universities (n = 3) and local communities (n = 3),[4,38,40] one from government data and charities,[41] one from an existing research database,[42] and one from a clinic.[37] Only five studies reported socioeconomic status of participants, ranging from between 49-66% of autistic adults being in part or full-time employment,[4,38,42] young people from advantaged families,[40] and one study with 50% of children receiving free school lunch.[43] 17 studies reported information about race, with most participants being white (including Caucasian) (30.7-100% across studies).

[INSERT TABLES 2]

Quality Appraisal Findings

Tables 2 and 3 summarise the quality scores of each reviewed study. There is a wide range in study quality, ranging from 0.5 to 0.95, with most of the studies scoring above .80. The wide range underscores the need to consider the study quality when interpreting findings. Additionally, the Friendship Survey used in most studies has not been validated with autistic individuals, and none of the reviewed studies reported psychometric properties of the measure. Finally, it is worth noting that the quality ratings did not include qualitative reviews, which could provide valuable information into autistic individuals' perceived satisfaction with their social network structure and its functional values.

Social Network Measure Characteristics

We identified several social network mapping tools across the 29 studies, with details summarized in Table 2. The majority of studies done in classrooms with children (n = 17 studies) employed the Friendship Survey,[44] where all children within a classroom rated their relationships with each other. One can use this information to generate a sociomap, including individuals' network centrality, network density, and degree of social connections. Relationship quality includes peer acceptance, rejection, and degree of reciprocity (see Table 1 for definition).

We identified four additional measures that were used to generate ecomaps (i.e., individual is asked to name social network members and rate the perceived quality of their relationship with each member), including the Maastricht Social Network Analysis (MSNA),[45] Network in Action Questionnaire (NiA), Arizona Social Support Interview Schedule (ASSIS),[46] and Social Network and Perceived Social Support (SNaPSS)[32] tools. Compared to the Friendship Survey, both MSNA and SNaPSS ecomap tools rely only on subjective ratings from the autistic individual to name up to 20 network members that they perceive to be important in their lives, and can capture network size and density, frequency and mode of communication, and length of relationships. Both ecomap tools asked individuals to rate their perceived social support from each network member, thus capturing social capital available to an individual within their reported social network. In contrast, the NiA and ASSIS asked participants to reflect on several areas in their daily lives and name network members they perceived to provide them with some level of support in each area. The final network structure included only network members who provide some degree of support and are perceived important to the individuals.

Bespoke social network measures were identified in a number of studies that captured social reciprocity amongst friendship and clusters (e.g., nominating the number of peers in a classroom each person most and least liked to play with [41]; how close you are to that friend)[42] through both questionnaires and observation scales (e.g., rating degree of intensity in social interaction to code social reciprocity during play time at school).[35] One study explored the use of duocentric networks[40] by matching the networks between an autistic young person and that of their parent, to explore the degree of overlap for social network members named by both young person and parent in their respective social network maps.

Characteristics of Social Networks: Summary of Friendship Survey based Results

A total of 17 studies used the Friendship Survey to capture social network structure in autistic children in relation to their neurotypical peers in the same classroom (Table 3a). For social network centrality, autistic children are reported to be more isolated and more likely to be found on the edge of social networks compared to their neurotypical peers[47–52] and peers with other disability,[50] and few autistic children have central status. The relationship between age and network salience showed some mixed results, with one study showing that older autistic and neurotypical children had lower social network centrality compared to younger peers,[48] whilst another suggested that social network salience increased for children across the grades 3-6 years old over the school year.[50]

Five studies involved a range of interventions (see Supplementary Materials B for summary of interventions) delivered by school personnel and peer mediated models to support autistic children in classrooms.[43,53–56] Researchers employed two main approaches: adult-mediated interventions, which involved providing autistic children with instructions on social rules, role-playing, and practice; and a peer-mediated approach, where trained peers engaged autistic children using taught strategies across school settings. Peer-mediated interventions were more effective than adult mediated intervention in improving social network connection.[53] Additionally, researchers have compared two interventions, a didactic approach with a more naturalistic intervention in which a group leader facilitated activities based on the preference of the autistic children and faded out supports as soon as children could play independently. The two interventions also varied in group composition (all autistic students vs. mixed group of autistic and nonautistic students). There was no group difference between the two approaches in social connections from the peer nomination measure.[53,54] Overall, peer-mediated interventions and adult-mediated programmes resulted in higher social network centrality compared to adult-facilitated strategies and inclusive classrooms with no additional social skills interventions.[56] Additionally, autistic children who received support from school staff who were trained to recognise children's social communication needs, sustain their engagement and facilitate peer interactions showed significant improvement in network centrality over the academic school year.[43]

Regarding peer acceptance and number of received nominations from peers in the classroom, autistic children had lower peer acceptance compared to neurotypical peers[47,49–52] and children with other disability.[50] One study found that all children received more friendship nominations over the course of one academic year,[50] and another found that those who received peer-mediated interventions also received more friendship nominations compared to other forms of treatment groups.[53]

Regarding peer rejection, social reciprocity decreased between peer nominations for older autistic and neurotypical children,[47] and autistic children nominated fewer peers as friends, and were nominated fewer times by other classmates as friends.[48] Autistic children received more non-preferred nominations over one academic year compared to neurotypical peers and peers with non-autism disability,[50] and were more likely to be rejected by peers.[52] One study found that autistic boys were more socially excluded compared to autistic girls.[57] Only one study found that autistic adolescents did not differ from their neurotypical peers in number of peer rejections received at various time points during the academic school year, and this may be related to the study having a slightly older adolescent age group compared to elementary school aged children.[51] Overall, autistic children showed lower social reciprocity in best friend nominations compared to neurotypical

peers,[47,48,51,52,57] though both autistic and neurotypical children were more likely to report reciprocal network connections with other girls in their classrooms. Finally, researchers in one study found that number of received friendship nominations and network inclusion partially contributed towards the amount of time autistic children spent in joint engagement with peers.[58] In contrast, number of rejections was not associated with joint engagement, suggesting the impact of rejection on social exclusion may be less visible during playtime.[58]

[INSERT TABLE 3]

Characteristics of Social Networks: Summary of Studies That Use Alternative Tools

Twelve studies used alternative measures other than the Friendship Survey to capture social network metrics (see Table 3b). The majority of studies in this group recruited from community, with two studies recruiting from universities,[33,34] three from schools,[35,39,41] one from an existing research database.[42]

Social Networks in Autistic Adults

Regarding older participants recruited from the community, researchers assessed social network size by asking participants to name up to five people who are important to their lives[40] or answering the question "how many friends do you have right now (people you spend time with?).[42] Findings reported different results depending on the number of network members capped within the measure. When being asked to name up to five people, the average network size for autistic young adults was 4.88.[40] For social network site users, when being asked how many friends one has,[42] the average size of network friends is 219, with median of 142. Autistic individuals who used social network sites reported to have met 56.7% of their social network in person, although information about the perceived quality of support provided by their network was unclear.[42]

Two studies made use of social support network measures, including the Arizona Social Support Interview Schedule[38] and Network in Action Questionnaire,[37] both asked autistic adults to name individuals within their social network who provided support in at least one area of their lives, ranging from physical and material assistance, to emotional and guidance support. Both studies found that on average, participants consistently named between 4-5 people who supported them in their daily lives, though some reported up to 21 people in their social network.[38] Both studies found that family members were often cited to form the majority of individuals' social networks and were perceived to be more available than

other types of social network members (e.g., partners, friends) for material and physical assistance, though partners were rated as most available for providing emotional support such as need to confide in, guidance, feedback and social participation.[38] Autistic adults also perceived themselves to be helpful for between 1-2 social network members.[37] Regarding frequency of contact, one study found between 19-21% of social network members named by autistic adults were seen either daily or at least once per week.[37]

Social networks in autistic youths transitioning to university

A series of studies used the Social Network and Perceived Social Support (SNaPSS) to understand the social network structure and perceived support among autistic students in their first year of university.[32–34] Researchers asked autistic young people to "name up to 20 people with whom they have been in contact with over the past three months, and whose relationships were perceived to be particularly important" to the individual. Individual differences in self-reported network size ranged from 2-20 members. On average, participants reported family members to provide better quality support compared to friends and others in the network. For autistic students, no change was found in network size, density, or the change in the makeup of their social network across the first year of university. However, the non-autism group showed a decrease in both network size, density and an increase in the proportion of friends (relative to family and other types of social network members) within their reported social networks across the first year of university.[34]

Social networks in school-age autistic children

Regarding studies that recruited school age participants,[35,41] one study used Behavior Rating Profile[59] and did not find any difference between children on the spectrum and the peers without disabilities in social preference, social impact, social network affiliation, acceptance, visibility, social network affiliation.[41] In the second study that included a school-aged participant (10 years of age), the researchers asked the target child and his classmates to list classmates that they have "a friendship relation with". Results from this study suggest that the target child received fewer friendship nominations on average than peers without disabilities. There is no relation between nominations and social interactions on the playground.[35] The third study was in a classroom setting in China,[39] where authors asked students to nominate three peers they liked and three peers they disliked in the class to measure social acceptance and rejection. Authors found that autistic children were more likely to be rejected or rated with an average degree of acceptance (i.e., neither liked nor disliked by other students) compared to neurotypical peers in the class.[39]

Discussion

What Measures Have Been Used to Assess Structural Characteristics of Social Networks in Autistic Individuals?

This is the first systematic review to evaluate the measurement of social network structure amongst autistic individuals. 17 of the 29 included studies generated sociomaps in school classroom settings using the Friendship Survey,[44] 3 studies used the Social Network and Perceived Social Support[32–34] tool to generate ecomaps amongst autistic students transitioning to first year of university, and other studies used a range of network analysis tools including bespoke social network measures that are summarised in Table 2. The Friendship Survey is relatively user-friendly and fast to administer, as it directly collected only five questions from students. The advantage of involving all students allows an objective social network to be constructed based on observable behavioral differences across social groups within a predefined social sphere and enables the quantification of a child's network centrality. A few limitations exist when interpreting this body of research. The majority of the studies came from one research group working with elementary school children in public schools in the US[43,53] and findings may be limited in cultural sensitivity and can benefit from replication from outside of the US. Second, the feasibility of measuring sociomaps within a predefined social sphere becomes much more limited across the course of development. As individuals leave a structured school classroom setting, they may begin to form relationships in multiple settings outside of one's main work and school environment, and the scale of how many informants are required to create a synthesized sociomaps may become more difficult.

To account for the increasing complexity in one's social network structure, ecomaps are more appropriate for adolescence and adulthood, as it enables the individual to recall network members from different walks of one's life that may be perceived to be important to that individual. Both Social Network and Perceived Social Support (SNaPSS)[32] and the Maastricht Social Network Analysis (MSNA)[45] relied on self-report to generate a single ecomap summarizing relationships between network members across different social settings, and can include both online and offline social networks. Ecomaps provide a visual prompt for individuals to explore the availability and flow of social capital within their existing social network relationships that an individual may or may not be explicitly aware of if one were to recall perceived social support in the absence of this visual map. For example, an individual may have a clear preference to go to the same person for different types of support and may become stuck if that person were to suddenly become unavailable. Ecomaps allow one to visualize and contemplate whether other existing network members may be able to serve a similar function to that of the preferred individual and may enhance an individual to make use of their social networks in a more flexible, adaptive, and

purposeful way. However, the reliance of ecomaps mostly on self-report may be subject to reporter bias. McGhee Hassrick and colleagues[40] have begun creating duocentric network maps from both autistic young people and their parents' accounts, and such inclusion of multiple informants to generate more reliable ecomaps is an important future direction to explore.

What Are the Characteristics of Social Networks Amongst Autistic Individuals?

Resonating with the social communication challenges faced by autistic individuals, studies using the Friendship Survey with elementary school students have yielded several important findings, such that autistic children are more socially isolated, receive lower peer acceptance and greater peer rejection from others, and nominate fewer peers as friends. Currently, the field of social networks among autistic individuals remains largely descriptive, with very few intervention studies conducted by independent researchers to provide effective means to change the social network structure.

This review highlights that knowledge about how social network structure changes across the lifespan is lacking. No studies adopted a longitudinal design across different developmental stages. The functional impact of social network structure is likely to be different depending on the developmental context. For example, in neurotypical individuals, although family networks are stable in size from adolescence to older age, networks with co-workers or neighbors were important only in specific life stages.[60] A large social network size is neither necessary nor sufficient to maintain wellbeing across development. For example, as one ages, people may intentionally seek a decreased network size to maintain stable emotional wellbeing.[61] However, little research is available on how patterns of social networks may change across development, and whether a consistently small social network profile may exert a similar impact on one's quality of life over time for autistic individuals.

A few studies provided preliminary evidence to suggest a sex difference amongst social networks of autistic children, such that younger autistic boys showed better social connectivity than autistic girls, though this effect lessened across age and autistic girls fared better in larger classroom sizes compared to autistic boys.[62] Differences in social connectivity may be associated with sex differences in social camouflaging (i.e., actively "hiding" one's social communication differences in an attempt to fit in),[9] such that girls are more sensitive to and employ a range of strategies to negotiate the changing social dynamics across development, and may be better able to do so when there are more alternative social groups in a larger classroom setting. However, the success of social camouflaging can vary greatly, especially in mainstream classrooms, and can come at a significant cost to the young person's mental health when their sense of belonging

is challenged.[63] Maintaining increased social connectivity in a larger social network may be negatively associated with quality of life and mental wellbeing for autistic individuals who engage in high levels of social camouflaging.[64] Furthermore, it is important to consider how gender identity across development may influence social network structural changes above and beyond that of sex differences, and no studies to date have distinguished between the impact of sex and gender on changes in social network structure over time. Future studies can benefit from exploring the intersection between camouflaging, social network structure, gender identity and perceived well-being amongst autistic individuals to understand the impact of gender and gender identity on social network changes across development.

Finally, only five of the included studies were intervention studies. This is consistent with previous systematic reviews[65] which found that not many social skills intervention studies examine social network changes as an outcome measure. Only one of the five intervention studies found autistic children who received support from school staff showed significant improvement in social centrality. Thus, there is no evidence to suggest that these interventions have an impact on peer acceptance indicated by the likelihood of being nominated as friends. One area targeted by interventions is the percentage of time an autistic child initiates a conversation and sustains the play with their peers. However, our findings seem to suggest that teaching social skills, using directive or peer-mediated interventions, may not lead to peer acceptance.[58] In other words, social skills training that solely focuses on skill acquisition may not lead to changes in the perception of neurotypical individuals regarding their autistic peers. Rather, efforts at a system level (e.g., classroom, workplace) teaching others to understand and respect autistic individuals are equally important.[66] Furthermore, no intervention studies looked at social network changes beyond elementary school age. Given that many major life events and transitions happen during the periods of adolescence and young adulthood, it is important for future research to focus on social network structural changes during such transitions and understand the implications on autistic individuals' ability to access instrumental, emotional, and informational support from their support networks.[34]

Clinical Implications

Our review has several important clinical implications in both assessing social network characteristics and intervention services for autistic populations. For assessment, practitioners in education and clinical settings may consider adopting a social network measurement to capture real-time changes in structure and function of different social relationships that are meaningful to the autistic individual. We recommend education practitioners to consider the value of adopting a sociomap measure such as Friendship Survey when working with younger children in structured classroom settings, to

understand network size, centrality and peer acceptance and rejection of the autistic child through their own eyes and that of their peers. The Friendship Survey is easy to administer, consisting of only five questions, but yields important information regarding social relationships of autistic children in the context of schools. When working with autistic adolescents and adults who may have more complex social environments across multiple settings, we recommend practitioners to consider adopting a sociomap measure that allows easy quantification and visualization of meaningful relationships to that individual in daily life, to develop a holistic understanding of social resources that may or may not be available to that individual to meet different demands in life. We highlight the strength of social network maps being highly person-centered. Given little is known about the relationship between social network structure and function, it is important for clinicians to work together with autistic individuals to understand the extent to which they feel able to draw on existing relationships in a meaningful way. Identifying social network structure enables practitioners to understand the complexity of systemic influences within an autistic individual's environment and extend work into the community to promote understanding and acceptance of neurodiversity. Understanding how an autistic individual is currently embedded within their social network may enable practitioners supporting autistic individuals to consolidate and potentially expand their social connections in a way that is meaningful to them. Proceeding from the autistic individual's perspective of their social network might also help address the double empathy problem.[6,7] The double empathy problem highlights that social communication differences between autistic and non-autistic individuals extend both ways, and there is a need for non-autistic individuals to take ownership and foster curiosity to explore communication differences and improve mutual understanding. Understanding an autistic individual's social world from their own perspective and scaffolding meaningful social opportunities may contribute towards improving their quality of life through person-centered care and shift away from focusing solely on quantity of social connections.

Limitations and Future Research Directions

The current systematic review highlighted several limitations in the field of understanding social network structure in autistic individuals. First, most studies used the "Friendship Survey" to generate sociomaps in the elementary school setting, and the generalizability of using this measure across later stages of development when complexities of social relationships increase across home, work and recreational domains is much more limited. Second, as the current study chose to focus on identifying social network structural changes across the lifespan, we found that few studies examined co-occurring changes in perceived social support that would provide insight into the functional utility of one's social network over time. Future research may also consider the value of using ecomaps to capture social connections more accurately across

different settings and environments for autistic children and young people. Given that many families of autistic young people may scaffold social opportunities outside of education/classroom settings that may be better tailored towards the young person's focused interests and strengths, ecomaps may accurately reflect meaningful social connections across a young person's social sphere that is not limited to one setting. For autistic adult, sociomap may also be beneficial to understand the nuances of social connections within a defined social setting, such as in the workplace or in higher education. Understanding social connections in well-defined social settings can help identify both established connections and access to support and highlight gaps where reasonable adjustments may be needed to enable the autistic individual to participate and contribute to their social environment.

The current review highlights the utility of social network analysis as descriptive tool that can visually capture the current state of an autistic individuals' social connections. The interpretation of social network metrics needs to be carefully done together with the autistic individual to understand: 1) what are their social needs and goals; 2) the extent to which those goals are met by their current social network; 3) and if not – what are some ways to improve social connections in a way that is most meaningful to the autistic individual. We place greater emphasis on the double empathy problem,[6] highlighting the caveats of imposing social network theories largely based on neurotypical populations to autistic individuals' social networks. The focus on size, density, and network centrality metrics from social networks may not linearly correlate with relationship satisfaction for autistic individuals. For example, the degree of autism acceptance modelled in each social connection by the social partner may influence an autistic individual's felt need to mask their differences, and ability to thrive in an authentic manner within that relationship. Such qualities of social networks may not be reflected by metrics such as size and density per se.

Taken together, this paper highlighted the need for future research to conduct more cross-sectional and longitudinal observational studies to investigate changes in one's sociomap and ecomap structure across development, and how changes in social network structure may correlate with perceived loneliness, social support, and individual wellbeing including mental health outcomes over time. Quantitative data on social network structure alone will not be able to offer insight into the quality and meaning of those social connections for autistic individuals in terms of meeting their social needs.[31] Triangulating data collection across multiple observers within one's social network may offer valuable insight into the perceived quality of social relationships within one's social network from multiple perspectives to be considered alongside the view of autistic individuals themselves. Synthesising information from multiple perspectives can potentially highlight relationships that are

more accepting and foster a positive autism identity for autistic individuals, versus other relationships that may be characterised by potential misunderstanding or miscommunication between the autistic individual and their social partner. We therefore advocate for more mixed methods study that incorporates social network structure as well as qualitative components to gain insight into how autistic individuals interpret their social connections. For example, exploring the relationship between social network metrics such as size and density, alongside social camouflaging and autistic identity may be important to understand the social burden for autistic individuals. Understanding the degree to which autistic individuals feel accepted by and can express their authentic self within social networks is crucial. Given recent literature on the importance of autistic identity to support wellbeing at both individual and community level, understanding different neurotype representation within autistic individuals' networks may provide insight into their connect with the wider autistic community. Practitioners need to scaffold social opportunities that strengthen existing relationships and/or fosters new ones in a way that is personally meaningful to the autistic individual, rather than imposed based on neurotypical social norms. Understanding the functional correlates of individual differences in social network structural changes across development can allow both professional stakeholders to identify both sources of social resilience that may buffer against stressful life events such as transitioning to a new school or work environment and anticipate potential ruptures and losses of social relationships that may negatively impact an individual's wellbeing over time.

The current study highlighted that despite the widespread prevalence of intervention targeting social skills with the implicit goal of improving social initiation and connection for autistic young people, there is limited use of social network metrics to evaluate longitudinal effectiveness of social skills training on the development and maintenance of social relationships across development. Given recent literature around the potential negative impact of social camouflaging on mental health in autistic adolescents and adults,[14,67] it is difficult to know how social skills taught at a younger age may interfere with the development of self and autism identity across the course of development and maintenance of social relationships in the context of one's social network. Future research and clinical work may benefit from explicitly monitoring changes in social network structure amongst autistic individuals over time, especially around major life transitions (e.g., changing schools, starting university or a new job). Social network maps provide valuable information in formulating whether the individual has any support needs that are not met through their current social network and problem solve how best to address that unmet need through intervention.

Conclusion

Meaningful social connections and social participation contribute towards quality of life for autistic individuals. Social skills intervention studies often include outcome measures such as autistic traits and social competence. Although these outcomes are important, they do not reflect autistic individuals' day-to-day life, nor do they capture who autistic individuals hang out with and whether they feel their needs being met through their social network. Our review reveals the importance of future research efforts to incorporate social network measures as a study outcome, to consider the validity of social skills goals in the long term and how meaningful they are to the autistic individual, and to develop instruments that can measure both structural and functional aspects of social networks, especially for autistic adolescents and young adults.

Conflicts of Interest

Authors declare no conflicts of interests.

Funding Information

No funding has been received or used for this systematic review.

Author Contribution Statement

JL, XQ, and KM conceptualised and co-authored the article. All authors contributed towards data screening and extraction. JL and XQ led data synthesis and initial drafting of the manuscript. KM participated in narrative synthesis, review, and revision of the manuscript.

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Figure 1

PRISMA Flow Chart showing selection of studies included in narrative synthesis.

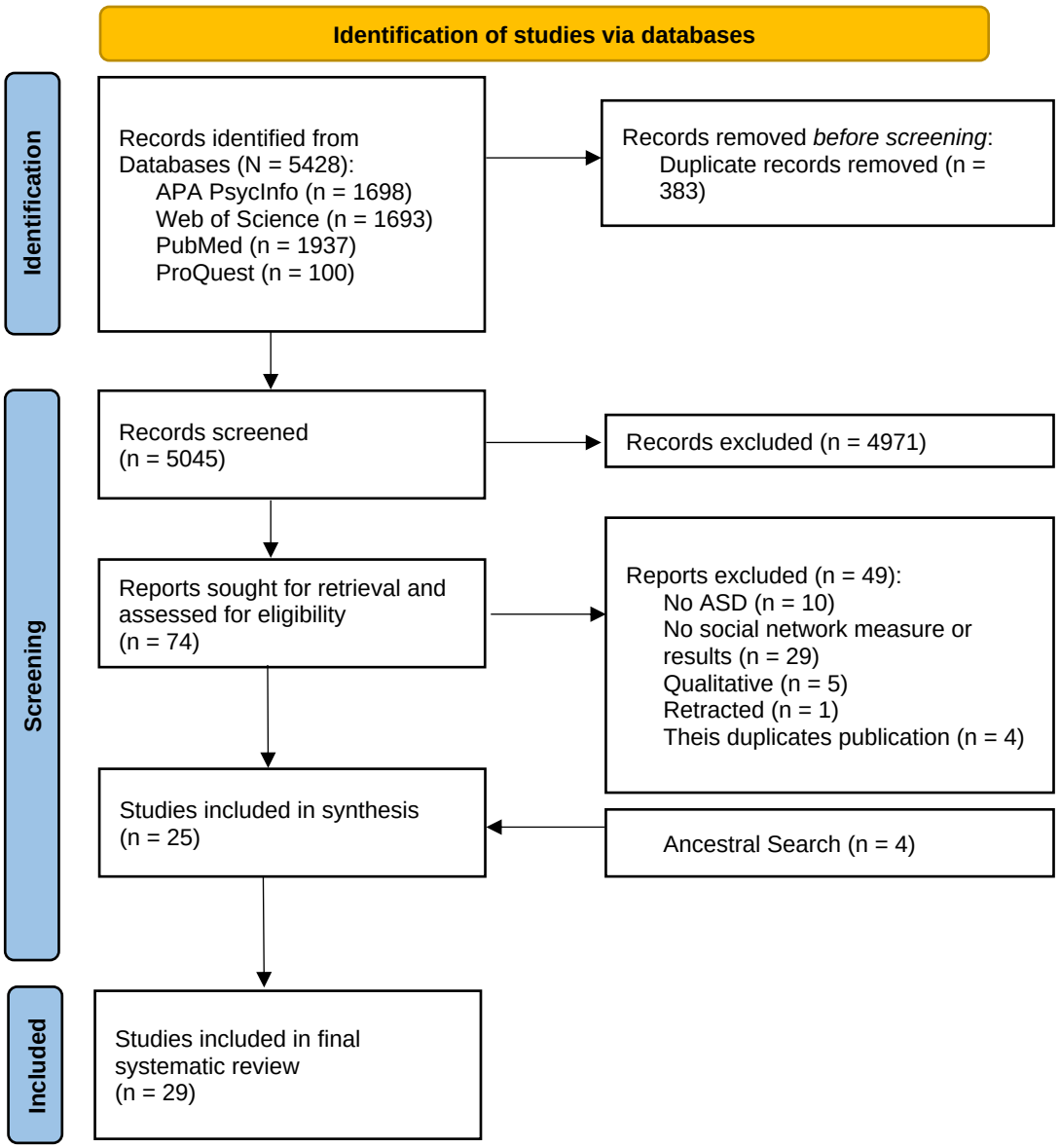


Table 1

Social network structural characteristics and key terms

Network Key Terms	**Definition (Borgatti et al., 2018)**
Social Network Analysis	A way of thinking about social systems that focuses our attention on the connections or relations among the entities that make up the system.
Ego-centric/Ego-centered	A social network research methodology where an individual is asked to name people they perceive to form part of their social network (those whom they have social connections with). Information about each of the named social network member is collected.
Sociocentric (Matous 2017)	A social network research methodology where all individuals within a set social space (e.g., in a classroom, in an office) are asked to provide information about their relationship with each other.
Network Structure	**Definition (Borgatti et al., 2018)**
Size	Number of people within a social network.
Density / Social Connection	The degree to which different people within a social network are connected to each other.
Centrality	The degree to which an individual is found at the centre of their social network.
Type of Connection	The relationship between the network member and the "owner" of that social network (i.e., the person whose social network is being mapped out).
Network Connection	**Definition**
Nomination	The process of naming of a social network member based on a specific quality. For example – naming 3 peers in a classroom you like to spend time with.
Acceptance	The degree or likelihood in which other network members rated you to be likeable versus unlikeable.
Rejection	The degree or likelihood in which other network members rated you to be unlikeable versus likeable.
Reciprocal	The degree or likelihood in which two network members rated each other similarly in terms of likeability.
Salience	An individual's prominence within a defined social setting, which depends on the individual's popularity and the popularity of their social group.

Table 2

Information captured by different instruments used to measure social networks (N = 29)

	Network Structural Characteristics				Relationship Quality							Network Function
Instrument	**Network Centrality**	**Network Size**	**Network Density/social connection**	**Type of Connection (e.g., Family, Peer, Professional)**	**Acceptance**	**Rejection**	**Reciprocity**	**Similarity**	**Contact Frequency**	**Mode of Contact**	**Length of Relationship**	**Perceived Social Support**
Friendship Survey (Cairns & Cairns, 1994) - Sociomap	**x**		**x**	**(Peer only - not relevant)**	**x**	**x**	**x**					
Chamberlain et al. (2007)	x				x	x	x					
Locke et al. (2010)	x		x		x	x						
Rotherm-Fuller et al. (2010)	x		x		x	x	x					
Kasari et al. (2011)	x		x			x	x					
Kasari et al. (2012)	x				x	x	x					
Calder et al. (2013)	x				x	x	x					
Locke et al. (2013)			x		x	x	x					
Dean et al (2014)			x		x	x	x					
Kasari et al. (2016)	x				x	x	x					
Anderson et al. (2016)	x											
Locke et al. (2017)	x		x		x	x						
Locke et al. (2018)	x		x		x							
Locke et al (2019a)	x				x							
Locke et al (2019b)	x											
Locke et al. (2019c)					x							
Santillan et al. (2019)	x				x	x	x					
Matthews et al (2020)	x				x	x	x					

Social Network and Perceived Social Support (Lei et al., 2019) - Ecomap		**x**	**x**	**x**				**x**	**x**	**x**	**x**	**x**
Lei et al. (2019)		x	x	x				x	x	x	x	x
Lei et al. (2020a)		x	x	x				x				x
Lei et al. (2020b)		x	x	x				x				x
Maastricht Social network Analysis (Baars 1994)		**x**					**x**	**x**	**x**	**x**	**x**	**x**
van Asselt-Goverts et al. (2015)		x					x		x	x	x	x
Network in Action Questionnaire		**x**							**x**	**x**		**x**
van den Heuvel et al. (2023)		x							x	x		x
Arizona Social Support Interview Schedule (ASSIS) (Barrera et al., 1981)		**x**		**x**								**x**
Jeanneret et al. (2023)		x		x								x
Bespoke Social Network Measure												
Boutot et al. (2005)			x				x					
Saldana et al. (2009)				x								
Mazurek et al. (2013)		x										
Rodriguz-Medina et al. (2018)	x	x	x				x					
Hassrick et al. (2020)	x	x	x	x								x
Xie et al. (2023)	x		x		x	x	x					

Table 3

a) Summary of studies (n = 17) that used the Friendship Survey to capture social network metrics in individuals with ASD

Authors (Year, Country)	**Sample Size (N, Male) Recruitment Channel**	**Diagnosis (criteria/ measure)**	**Age (M; SD) IQ (M; SD) Race (N; %) SES**	**Social Network Centrality (SNC) / Network connection**	**Peer Acceptance/ Nomination**	**Peer Rejection**	**Friendship Reciprocity**	**Quality Score**
Chamberlain et al. (2007); USA	ASD: 17 (14) Matched NT peers: 17 (14) NT: 381 (182) Recruitment: school	ASD: prior clinical diagnosis / school reports	Age: ASD/NT: 2nd - 5th graders FSIQ: ASD: 107.3 (Range: 89-129) Race: unknown SES: unknown	ASD vs. Matched group: ↓SNC - 35% peripheral (vs. 6%), 47% secondary (vs. 47%), 18% nuclear (vs. 47%) Both groups: ↑SNC = ↑Top 3 Reciprocity, ↑peer acceptance; SNC not associated with Best Friend Reciprocity for either group; ASD: ↑SNC = ↑"buddy" nominations received and closeness.	Peer acceptance: ASD < NT	ASD vs. NT: ↑age = ↓reciprocity of Top 3 friendship nominations ASD vs. Matched group: ↑grade = ↓reciprocity in best friend nominations; ↑ companionship	ASD vs. NT: ↓reciprocity at all "buddies" named, ↓"top 3" friends, ↓best friends. Nominated "buddies" > received nominations from peers. ASD vs. Matched group: ↓reciprocal Top 3 nominations ↓reciprocity with best friend both genders show ↑connections with girls	0.73
Locke et al. (2010); USA	ASD: 7 (4) NT:13 (not reported) Recruitment: school	prior clinical diagnosis	Age: ASD: 14.71 (1.11) NT: 14.20 (0.63) Race: White (5; 72) Black (1; 14) Asian (0; 0) Mixed/other (1; 14) SES: unknown	ASD: 71.4% of the time either isolated or peripheral Social network ratings: ASD < NT	Nominations: ASD (1.43) < NT (3.69) ASD: ↑identify another autistic adolescent as best friend	ASD > NT: rejection ASD < NT: perceived friendship	N/A	0.73
Rotherm-Fuller et al. (2010); USA	ASD: 79 (70) NT: 79 (70)	IQ: WISC-III	Age: 8.11 (1.07) FSIQ: 91.4 (17.3)	Isolation / Peripheral: ASD > NT	Acceptance: ASD < NT	ASD > NT: rejection	ASD < NT: reciprocal friendship	0.77

	Recruitment: school		Race: White (30; 38) Black (4; 5.1) Asian (11; 13.9) Other (20; 25.3) SES: unknown					
Kasari et al. (2011); USA	ASD: 60 (54) NT: 60 (54); matched on age and gender; same class as ASD group) Recruitment: school	ASD: ADI-R; ADOS IQ: WISC-III	Age: ASD: 8.14 (1.56) NT: 7.86 (1.43) FSIQ: ASD: 90.97 (16.33) Race: White (28; 46.7) Black (3; 5) Asian (10; 16.7) Mixed/other (19; 31.7) Unknown (0) SES: unknown	ASD < NT: SNC ↑Age = ↓SNC ASD > NT: Isolation (8 vs.0) Peripheral status (25 vs. 6) ASD < NT: Secondary status (22 vs. 35) Nuclear status (5 vs. 19)	N/A	ASD < NT: Friend nominations made and received; Classroom connections	ASD<NT: % of reciprocal friendship with nominated 3 best friends Reciprocal best friends	0.86
Kasari et al. (2012); USA*	ASD: 60 (25) Recruitment: school	ASD: ADOS	Age: 8.14 (1.56) FSIQ: 90.97 (16.33) Race: White (28; 46.6) Black (3; 5) Asian (10; 16.7) Other (19; 31.7) SES: unknown	PEER INT > CHILD:SNC PEER INT + CHILD > CHILD: SNC (PEER and CHILD are intervention conditions)	Received Nomination: PEER INT > CHILD; no group difference at 12 weeks follow up Outward Nomination: No group difference	No group differences: rejection	No treatment group differences: reciprocal friendship outward friend nominations	0.86
Calder et al. (2013); UK	ASD: 12 (8) NT: 11 (6)	ASD: prior clinical diagnosis	Age: ASD: 10 (3) NT: 10 (3) FSIQ:	ASD: 6 peripheral status 3 secondary status 3 nuclear status	Friendship group sizes: 1-10 children.	No child was isolated	Average reciprocal friendship = 60%.	0.86

	Recruitment: school		ASD: 95.17 (17.9) NT: 93.36 (18.49) Race: Unknown SES: unknown					
Locke et al. (2013); USA	ASD: 26 (21) Non-ASD disability: 76 (43) NT: 338 (161) Recruitment: school	ASD: school records, prior clinical diagnosis	Age: ASD: 7.84 (2.17) Non-ASD disability: 7.96 (1.93) NT: 7.53 (2.32) Race: White (12; 46.2) Black (1; 3.8) Asian (9; 11.5) Mixed/other (3; 38.5) SES: unknown	ASD vs. NT and non-ASD disability: ↓ social network salience across one academic school year All groups: ↑social network salience for grades 3-6	All groups: ↑friendship nomination over 1 year ASD < non-ASD Disability < NT: number of nominations	ASD > NT and non-ASD disability: non-preferred nominations over 1 year All groups: ↑non-preferred nominations over 1 year	ASD ≅ non-ASD disability and NT: best friend reciprocity non-ASD disability < NT: best friend reciprocity	0.86
Dean et al. (2014); USA	ASD: 50 (25) Non-ASD disability: 50 (25) Recruitment: school	ASD: ADOS	Age ASD: 6-10 NT: 6-10 FSIQ: ASD female: 90.72 (13.81) ASD male: 91.76 (13.75) Race: unknown SES: unknown	ASD < NT: social salience	ASD: ↑acceptance by same gender	ASD>NT: Social exclusion ASD Boys > ASD Girls: social exclusion	ASD<NT: Nominations ASD boys and girls have similar numbers of nominations	0.95
Kasari et al. (2016); USA*	ASD: 148 (109) ENGAGE: 82 (61) SKILLS: 66 (48)	ASD: prior clinical diagnosis	AGE: ENGAGE: 8.13 (1.55) SKILLS: 8.23 (1.63) FSIQ: ENGAGE: 91.98 (16.37) SKILLS: IQ: 92.93 (16.12) Race: ENGAGE:	ENGAGE = SKILLS: ↑Social network salience over time (ENGAGE and SKILLS are intervention conditions)	SKILLS > ENGAGE: time children spent with others during playtime	SKILLS < ENGAGE: isolation during playtime	SKILLS = ENGAGE: number of nominations by ASD number of nominations including ASD	0.95

	Recruitment: school		White (32; 48.75) Black (12; 15) Asian (14; 17.5) Mixed/other (17; 21.25) Unknown (6, 7.5) SES: unknown SKILLS: White (23; 40.35) Black (6; 11.32) Asian (14; 24.56) Mixed/Other (10; 17.55) Unknown (4; 7.02) SES: unknown					
Anderson et al. (2016); USA	ASD: 182 (135) NT: 152 (88) Recruitment: school	ASD: prior clinical diagnosis	ASD: Age: 8.4 (1.52) FSIQ: 92.31 (14.16) Race: White (64; 35.16) Black (35; 19.23) Asian (26; 14.29) Other (27; 14.84) Unknown (30; 16.48) SES: unknown NT: Age: 8.4 (1.5) FSIQ: unknown Race: unknown SES: unknown	Female autistic children: ↑connections in classrooms with ≥21 people Male autistic children: ↑connections in classrooms with ≤20 people ↑loss of connectivity in larger classrooms ASD: ↓Age = Male > Female in social connectivity ASD < NT: Social connectivity over the year.	N/A	N/A	N/A	0.91
Locke et al. (2017); USA	ASD :148 (131) Recruitment: school	ASD: ADOS IQ: WISC-IV; SB-5; DAS-II	Age: 8.37 (1.66) FSIQ: 91.16 (15.11) Race: White (46; 30.7) Black (14.5; 9.8) Asian (37; 25.2) Mixed/other (51; 34.3)	Social network salience: Predicted by number of received friendship nominations, autism symptom severity, and peer connections	Peer nominations positively associated with peer engagement and social network salience	Rejection did not predict social network salience	N/A	0.95

			SES: unknown					
Locke et al. (2018); USA	ASD:126 (19) Recruitment: school	ASD: ADOS IQ:SB-5 DAS-II	Age: 8.46 (1.48); FSIQ: 91.52 (14.92) Race: White (118; 39) Black (31; 25) Asian (20; 16) Mixed/other (5; 4) Unknown (21; 16.5) SES: unknown	Social network salience not associated with differences in sex composition in peer group.	Friendship nomination not associated with differences in sex composition in peer group.	N/A	N/A	0.86
Locke et al (2019a); USA*	ASD:31 (27) Recruitment: school	ASD: diagnosis made by a community clinician	Age: Remaking recess (RR): 9 Remaking recess with implementation support (RR+IS): 8.6 FSIQ: 65 or higher Race: – RR: White (5; 35.7) Black (5; 35.7) Asian (1; 7.1) Other (3; 21.4) Race: – RR+IS: White (10; 58.8) Black (5; 29.4) Asian (2; 11.8) Other (0) SES: 50% received FRL	RR+IS > RR: Improvement in SNC RR: ↑SNC over time.	RR+IS = RR: number of friendship nominations over time. RR+IS = RR: number of friendship nominations	N/A	N/A	0.95
Locke et al. (2019b); USA*	ASD: 92 (81) Practice-based	ASD: school records	PM: Age: 8.71 (1.27) Race: White (13; 92.9) Black (0)	PM <. RM: SNC (1.29 vs. 1.78, p= .05) IM < RM: SNC (1.27 vs. 1.78, p<.001)	N/A	N/A	NA	0.91

	model (PM): 14 (11) Research-based model (RM): 45 (40) Inclusion only model (IO): 33 (30) Recruitment: school		Asian (0) Other (1; 7.1) SES: unknown RM: Age: 8.22 (1.54) Race: White (19; 42.2) Black (3; 6.7) Asian (8; 17.8) Other (11; 24.4) SES: unknown IO: Age: 8.50 (1.93) Race: White (16; 48.5) Black (3; 9.1) Asian (3; 9.1) Other (4; 12.2) SES: unknown					
Locke et al. (2019c); USA*	ASD: 4 (4) Recruitment: school	ASD: ADOS IQ: DAS-II	Age: 9 (1.4) IQ: 88.3 (20) Race: unknown SES: unknown	N/A	Inclusion: Baseline: 0.16 End of Treatment: 0.22 Follow-up: 0.13	N/A	N/A	0.95
Santillan et al. (2019); USA	ASD: 55 (46) Recruitment: school	ASD: prior clinical diagnosis IQ: prior testing	Age: 8.65 (1.73) IQ: >65 Race: White (30; 54;55) Black (14; 25.45) Asian (3; 5.45) Other (8; 14.55) Unknown (0) SES: unknown	Isolated: 12.7% Peripheral: 49.1% Nuclear: 7.3%	Joint engagement: 11% variance accounted by number of received friendship nominations	Joint engagement not associated with total number of rejection nominations	Joint engagement: 11% variance accounted by inclusion	0.95

Matthews et al. (2020); USA	ASD: 10 (9) Recruitment: school	ASD: ADOS IQ: KBIT	Age: 14.90 (0.99) FSIQ:103.8 (19.98) Race: White (9; 90) Black (0) Asian (0) Other (1; 10) SES: unknown	ASD > NT: Isolation / Peripheral status at all time points (1st Year: end of fall and spring semester; 2nd Year: end of fall semester) ASD: ↑social isolation at end of fall semester (2nd Year)	ASD < NT: Acceptance at all timepoints.	ASD = NT: Rejection at all timepoints.	ASD < NT: Reciprocal best friendships (28.6% vs. 57.1%)	0.85

Note. ASD = Autism Spectrum Disorder; ADI-R = Autism Diagnostic Interview-Revised; ADOS = Autism Diagnostic Observation Schedule; DAS-II = Differential Abilities Scale - 2nd Edition; NT = Neurotypical; WISC-IV=Wechsler Intelligence Scale for Children, fourth edition; SB-5 = Stanford-Binet Intelligence Scale-fifth edition; DAS-II=Differential Ability Scales; KBIT-Kaufman Brief Intelligence Test; SES = Socioeconomic status. *Indicates study included an intervention and used social network measure as outcome variable (see Appendix B for intervention components).

b) Summary of studies (n = 12) using alternative measures to capture social network metrics in individuals with ASD

Authors (Year, Country)	**Sample Size (N, Male) Recruitment channel**	**Diagnosis (criteria/ measure)**	**Age (M; SD) IQ (M; SD) Race (n, %) SES**	**Social Network Measure**	**Social Network Findings**	**Quality Score**
van den Heuvel et al. (2023); The Netherlands	ASD: 193 (138) Recruitment: Clinic	ASD: prior clinical diagnosis; SRS-A	Age: 36.7 (12) Race: Unknown SES: Unknown	Network in Action Questionnaire - Participants named up to five key social contact for each life area deemed important to them (max 8 areas)	Network size (max 40, i.e., 5 for each of 8 life areas): 4.53 (SD = 3.78) network members either hindering/supportive across all life areas. Frequency of contact with network members (%): Daily: 21.7%; Face-to-face once per week: 19.5%; Face-to-face once per month: 17.7%; multiple times per week: 14.4%; multiple times per year: 13.5%; face-to-face once per year: 9% Perceived social support (range 1-3): Across the life areas, average support is 2.44 (SD = 0.41, median = 2.5) Perceived social hindrance (range 1-3): Across the life areas, average hindrance is 1.55 (SD = 0.51, median = 1.49) Network satisfaction (range 1-5):	0.91

					Across social network, average satisfaction is 2.8 (SD = 1.08, median = 3) Social reciprocity in support (max 5 per area): Participants reported themselves to be helpful for on average 1.91 network members (SD = 1.79, median = 1)	
Xie et al. (2023); China	ASD: 14 (14) NT: 12 (6) Recruitment: School	ASD: prior clinical diagnosis	Age: ASD: 7.21 (0.43) NT: 6.42 (0.51) Race: ASD: Chinese (14; 100) NT: Chinese (12; 100)	Peer nomination: each child asked to nominate 3 peers they like (positive) and 3 they dislike (negative) from class roster	Network centrality: ASD: 4 children socially isolated from social networks (i.e., no nominations received) - neglected by peers. 5 children on the edge of social networks - no mutual relationships were established with others in the class Acceptance: ASD: 0 were rated as popular (positive > negative) or controversial (positive same as negative) 6 rated as average acceptance (i.e., neither accepted nor rejected) NT: 5 rated as popular, 3 rated as average, 2 rated as controversial Rejection: ASD: 6 rated as neglected (few positive or negative), and 6 rated as rejected (negative > positive) NT: 2 rated as rejected	0.77
Jeanneret et al. (2022); France	ASD: 176 (58) - formally diagnosed; 46 (10) self-identify Recruitment: community	ASD: formal diagnosis, self-identify; AQ-10	ASD (formal): Age: 36.47 (11.25) IQ: Unknown Race: 7 (4) in racialised group SES: 114 (66) employed ASD (self): Age: 38.85 (9.87) IQ: Unknown Race: 3 (6.5) in racialised group SES: 33 (71.7) employed	Arizona Social Support Interview Schedule (ASSIS) (Barrera et al., 1981)	Network size: Personal support network up to 21 people (M = 5.33, SD = 3.68) Social network composition (% of social networks): ≥1 family member (65.3%), close friends (61.7%), romantic partners (41.4%), formal ties (27.9%), associative ties (10.4%), community ties (1.4%) Perceived support - who provided if available?: Material assistance key support: family (78.5%), partners (45.9%), friends (23.6%) Physical assistance key support: family (59.3%), partners (55.8%), friends (36.6%), neighbours and roommates (6.9%) Need to confide key support: partners (71.1%), friends (60.7%), family (42.3%) Guidance key support: partners (41.9%), family (40.5%), friends (36%), formal ties (23.6%), associative ties (8.1%) Feedback key support: partners (62.1%), friends (36.4%), family (26.3%), formal ties (26.3%) Social participation key support: partners (69.3%), friends (63.3%), family (17.2%) Perceived support- availability?	0.91

					Absence of support - no one to rely on for guidance (49.3%), feedback (46.8%), social participation (42.3%), material support (34.8%), physical assistance (34.7%), confide in (24%)	
Hassrick (2020); USA	ASD: 17 (10) Recruitment: community snowball	ASD: self-report ASD diagnosis	Age: 23.25(3.6) Race: unknown SES: advantaged families	Participants named up to five people who are very important to them; parents identified five people who have helped their young adult and types of support these people provided	Network size: ASD: The average network size for autistic young adults was 4.88 Network density Whole group (n=17): network density is .67. Young adult-parent matched pairs (n=3): 2 parents reported lower density compared to young people by naming alters who did not know each other. Social network composition: Family (61%), community (36%), e.g., friend, peer mentor) and professionals (4%) Perceived support: Most accessed: Friendship (75%), emotional support (74%) and advice (73%) Least accessed: Employment support (24%)	0.75
van Asselt-Goverts et al. (2015); The Netherlands	ASD: 30 (20) ID: 33 (16) NT: 42 (19) Recruitment: community	ASD: prior diagnosis, receiving MEE support ID: prior diagnosis, in care organisation	Age: ASD: 29.7 (4.7) ID: 28.9 (5.2) NT: 28.4 (4.8) Race: unknown SES: 60% of ASD group employed	Maastricht social network analysis (Baars 1994): adaptations using genogram and ecogram	Network Size: ID/ASD < NT Network Composition: ASD < NT: Network members, informal network members and family members on the MSNA ID vs. ASD/NT: ↑professionals, ↓acquaintances Frequency of contact: ID vs ASD/NT: ↑face-to-face contact with their acquaintances; ↓internet contact with professionals Length of relationship: ID vs. ASD/NT: ↓time known acquaintances, similar time for professionals Initiation of contact: ID/ASD vs. NT: ↓reciprocal initiation for family network and network of acquaintances ID vs. NT: ↑initiation for the family network and network of acquaintances ASD vs. NT: ↓initiation compared to network member (acquaintances, not family) Functional characteristics: Affection: ID/ASD vs. NT: Family < Professionals Connection: ID vs. ASD/NT: ↓for network members (in particular to family when compared to NT) Preference: ID/ASD vs. NT: ↑ for professionals	0.5

					Practical/informational support: ASD vs. NT: ↓support from acquaintances	
Lei et al. (2019); UK	Part 1: ASD: 10 (8) Recruitment: university	ASD: prior clinical diagnosis	Age: Part 1: ASD: 17.9 (0.74) Race: unknown SES: unknown	Social Network and Perceived Social Support (Lei et al., 2019)	Part 1: (ASD only) Social network structure: Size: 2-20 members Density: 0-1 ↑Social communication difficulties = ↓% friends and ↑% other network members; not associated with network size/density Perceived social support: Frequency and quality: Family > friends, other network members	0.86
Lei et al. (2020a); UK	ASD: 21 (11) NT: 182 (36) Recruitment: university	ASD: prior clinical diagnosis	Age: ASD: 18.33 (0.48) NT: 18.27 (0.50) Race: White (21; 95.2) Black (0) Asian (1; 4.8) Other (0) SES: unknown	Social Network and Perceived Social Support (Lei et al., 2019)	Changes in Social Network Structure (over first year of university): NT: ↓size and ↓density over time; ↓%family and ↓%other members, ↑%friends ASD: no change in size or density over time; % of friends > family > other network members Changes in Perceived Social Support: By network member over time: NT: ↓quantity and quality of support over time; friends > family/other network members; ASD: family and friends > other network members; By domain of support over time: NT: ↓quantity and quality of support over time; daily living skills > socialisation>academic ASD: daily living and socialisation areas > academic	0.86
Lei et al. (2020b); UK	ASD: 28 (14) NT: 28 (15) Recruitment: university	ASD: prior clinical diagnosis	Age: ASD: 18.32 (0.48) NT: 18.39 (0.50) Race: White (26; 92.9) Black (0) Asian (2; 7.1) Other (0) SES: unknown	Social Network and Perceived Social Support (Lei et al., 2019)	Social network structure: Size: NT > ASD Density: NT ≅ ASD Composition: NT and ASD: friends >family and other network members. Perceived social support: Quantity: NT and ASD: family > friends and other network members Quality: NT and ASD: family and friends > other network members	0.91
Boutot et al. (2005); USA	ASD: 10 (10) NT:141 LD, BD, ADHD: 26	ASD: prior clinical diagnosis IQ:	Mean grade level = 3.8 Race: White (10; 100) Black (0)	Behavior Rating Profile (Brown and Hammill, 1990), network affiliation	ASD ≅ TD: social preference, social impact, social network affiliation, acceptance, visibility, social network affiliation	0.73

	Recruitment: school	TONI KABC WISC-III	Asian (0) Other (0) SES: unknown			
Saldana et al (2009); Spain	ASD: 74 (63) Recruitment: government and support groups	ASD: Childhood autism rating scale	Age: 24.6 (5.8) Race: unknown SES: unknown	Bespoke social network size questionnaire (name and identity of members from three social networks: help with personal care, provide emotional support, participate in leisure activities)	Combining all 3 social networks: - 7% had mother as sole network member - 34% had two different people in social network - In ≥1 network: 96% had mother; 74% had father; 65% had extended family members, 40% had helpers/other practitioners, 39% siblings, 9% friends.	0.77
Mazurek et al. (2013); USA	ASD: 108 (57) Recruitment: Interactive Autism Network (IAN) Research Database	ASD: prior clinical diagnosis	Age: 32.4 (12.4) Race: unknown SES: 49.1% employed ≥ half time	Network size: "how many friends do you have right now (people you spend time with)" friendship closeness Unidimensional Relationship Closeness Scale (Dibble, Levine, & Park, 2012)	Network size: - Among social network sites (SNS) users, average social network size for friends is 219, median of 142, ranging from 0 to 1100 - SNS users reported to have met 56.7% of their social network friends in person Friendship closeness: SNS users ≅ SNS non-users	0.75
Rodriguz-Medina et al. (2018); Spain	ASD:1 (1) NT: 14 (8) Recruitment: school	Autism: CAST IQ: WPPSI	ASD: 10.25 Race: unknown SES: unknown	The number of classmates that listed the child as "has a friendship relation with…" The number of outward friendship nominations by the child (the number of classmates the child	Social network centrality for the autistic child: - Received 5.8 friendship nominations on average, < NT peers (6.93) - Lower level of agreement between self-rated friendship nominations with the classroom-consensus based on peer reports; - Little relationship between reciprocal nominations and real social interaction in playground	0.94

				listed as “has a friendship relation with”		

Note. ASD = Autism Spectrum Difference; AQ-10 = Autism Quotient-10; TONI=Test of Nonverbal Intelligence; KABC=Kaufman Assessment Battery for Children; WISC-III: Wechsler Intelligence Scale for Children-III; CAST: the Childhood Autism Spectrum Test; SES = Socioeconomic status; SRS-A = Social Responsiveness Scale - Adult; WPPSI-III: Wechsler Preschool and Primary Scale of Intelligence

SOCIAL NETWORK IN AUTISM

Supplementary Materials

A. PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	title page
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	abstract page
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	p. 2-3
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	p. 3
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	p. 4
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	p. 3
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	p. 3
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	p. 3
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	p. 4
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	p. 5
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	p. 5
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	NA - part of quality appraisal tool - Kmet et al. (2004)
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	NA
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	NA
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	NA
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	NA
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	NA

Section and Topic	Item #	Checklist item	Location where item is reported
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	NA
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	NA
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	NA
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	NA
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	p. 5-6
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	Fig 1. Prisma Chart
Study characteristics	17	Cite each included study and present its characteristics.	p. 6, Tables 2, 3 & 4
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	NA - Quality Appraisal Score reported
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Tables 2, 3 & 4
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	Tables 2, 3 & 4
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	NA
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	NA
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	NA
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	NA
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	NA
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	p.10-15
	23b	Discuss any limitations of the evidence included in the review.	p.14
	23c	Discuss any limitations of the review processes used.	p.14
	23d	Discuss implications of the results for practice, policy, and future research.	p.13-14
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	Not registered
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	Contact

Section and Topic	Item #	Checklist item	Location where item is reported
			authors for review protocol
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	NA
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	p. 15
Competing interests	26	Declare any competing interests of review authors.	p. 15
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	Contact authors for template data collection form

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

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B. Summary of Intervention Studies (n = 5)

Study	Condition	Intervention Components			
		Group format with typical peers	**Group format: no typical peers**	**Adult mediated**	**Peer mediated**
Kasari et al., 2012	CHILD condition	X		X	
	PEER condition		X		X
Kasari et al., 2016	ENGAGE condition	X (from same classroom)		X	
	SKILL condition	X (from different classroom)		X	
Locke et al., 2019a	Remaking Recess with implementation support provided to school	X		X	
	Remaking Recess without implementation support	X		X	
Locke et al., 2019b	School personnel implemented	X		X	
	University researcher implemented	X		X	X
	Standard educational practice (no targeted intervention)				
Lock et al., 2019c	Four children from grades 1-5 exposed to Remaking Recess intervention	X		X	

Note. In Kasari et al., (2012) study, CHILD condition is more adult-directed and PEER condition refers to training peers to facilitate interactions. In Kasari et al. (2016) study, adults in the SKILL group provided explicit instruction on social skills whereas they served more as a facilitator in the ENGAGE group.