



Non-reciprocal Friendships in a School-Age Boy with Autism: The Ties that Build?

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Abstract

This mixed-methods study examined differences in social interaction patterns between a school-age boy with autism and his friends, non-reciprocal friends, and non-friends during recess time at a mainstream school (third grade of elementary school). Through a combination of observational methodology and social network analysis with an idiographic, follow-up and multidimensional design approach, we used lag sequential and polar coordinate analysis to ascertain the associations between various interactive behaviors as a function of type of friendship relation. After 40 sessions, we found that the non-reciprocal friendship relations of the boy with autism could have significantly greater potential than his reciprocal friendships to increase active engagement and reduce the time he spent alone during recess.

Keywords Autism spectrum disorder · Elementary school · Friendship · Observational methodology · Recess · Social network analysis

Introduction

Friends play a decisive role in social, cognitive, and emotional development during childhood and adolescence (Vitaro et al. 2009; Hartup 1996). The latest revision of the *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; American Psychiatric Association 2013) includes difficulties in making friends as a diagnostic criterion for autism spectrum disorder (ASD). Compared with their typically

developing peers, children with autism usually are situated on the periphery of their social networks (Locke et al. 2013); score lower in their perception of various aspects of friendship quality, including companionship, closeness, intimacy, and help (Chamberlain et al. 2007; Locke et al. 2010; Solomon et al. 2011); and have fewer reciprocal friendships (Calder et al. 2013; Kasari et al. 2011; Petrina et al. 2014). In mainstream school environments, children with autism tend to interact less with their peers. They initiate and respond to social interactions less frequently than their typically developing peers, and without specific interventions they tend

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to spend recess time alone (Kasari et al. 2012; Locke et al. 2015).

Although the social interaction of people with autism has been a central area of research in this field for decades (Camargo et al. 2014; McConnell 2002; Reichow et al. 2012), we are still a long way from understanding precisely what these individuals understand by *friendship*, what conditions are most favorable for children with autism to establish and maintain friendship relations, and what characteristics define these relationships (Calder et al. 2013; Petrina et al. 2014). Most of what we know is based on clinical criteria and evaluations and on the analysis of self-reports and reports by relatives, teachers, or caregivers, and few observational studies have been carried out to date in natural contexts (Bauminger et al. 2008, 2017).

Although there is evidence to suggest that children with ASD have fewer friends than others types of children with special educational needs (Rowley et al. 2012; Solish et al. 2010), research in this area has revealed a large amount of variability (Locke et al. 2017) and clear differences in other friendship characteristics between children with ASD and their typically developing peers (Mendelson et al. 2016). Children with autism generally tend to find it more difficult than their typically developing peers to initiate, develop, and maintain long-term friendships. Frequency of contact with friends outside of school is lower in children with autism than in their peers (Bauminger and Shulman 2003; Bauminger et al. 2008). Children with autism participate in fewer activities, with a smaller number of participants, and in a more limited range of locations (Bauminger and Kasari 2000; Hilton et al. 2008); therefore, school is likely to be one of the contexts in which these children have the most opportunities to interact with their peers and make friends.

Research has also suggested that children with autism are generally less satisfied with their friendships than typically developing children, although the differences between the two groups do not appear to be significant (Petrina et al. 2017). However, the differences between how children with autism and their typically developing peers understand the value and purpose of friendship are poorly understood (Calder et al. 2013). Children with autism have difficulties identifying and defining the basic components of friendship (Bauminger and Kasari 2000; Carrington et al. 2003) and although they have theoretical knowledge about what it means to be and have a good friend, they have difficulty applying this knowledge in a practical way (Locke et al. 2010).

Moreover, the processes that contribute to the development of friendship relations in children with autism have not been studied in depth (Bauminger et al. 2010). The reciprocity of their friendships is especially low. Kasari et al. (2011) found that only 18% of children with autism have reciprocal friendships—compared with 64% of their peers—and

argued that these children's friendships are better described as unilateral rather than reciprocal. The authors suggested that future research should attempt to determine the extent to which these unilateral relationships can satisfy similar needs as reciprocal friendships (Kasari et al. 2011).

In studies of the characteristics of friendship relations between children with autism and their peers, reciprocity of friendship nominations has usually been considered a valid indicator of the existence of such a relationship between two children (Petrina et al. 2014). Sociometric procedures for peer nominations have frequently been used, although this could be problematic given the results of classic studies on informant accuracy regarding social relationships (Bernard et al. 1984; Holland and Leinhardt 1973; Neal 2008) and the peculiar ways in which children with autism recognize, describe, and express friendship and its qualities (Bauminger and Kasari 2000).

Reciprocity and social network centrality have been examined, mainly through study designs involving peer nominations or social cognitive maps (Cairns and Cairns 1994) or a combination of these two types of design (Anderson et al. 2016; Calder et al. 2013; Kasari et al. 2011). Compared with their typically developing peers, children and adolescents with ASD have lower reciprocity levels in their nominations of their three best friends and their best friend. Although these procedures can provide information about the agreement between the members of a dyad regarding the existence (or non-existence) of a friendship relation, they cannot determine the extent to which children with autism and their peers perceive the social network structure differently. Moreover, some researchers have argued that limiting the number of nominations can lead to errors in the identification of friendships (Berndt and McCandless 2009; Furman 1996) and that subtle differences exist between non-reciprocal and non-symmetrical friendship relations (Carley and Krackhardt 1996; Olsen et al. 2012).

As Laghi et al. (2014) pointed out unilateral friendships are a relatively unexplored phenomenon, although some differences between reciprocal and unilateral friendships have been identified. Children with reciprocal friendships show greater positive involvement in the relationship, greater stability, and more empathy than children with non-reciprocal friendships. Adams et al. (2005) found differences not only in the frequency of positive interactions such as conversation or joint attention but also in levels of aggression towards peers. In addition, children with reciprocal friendships perceive themselves as more similar to and cohesive with their friends and exhibit a deeper understanding of emotions than children with unilateral friendships (Laghi et al. 2014).

In relation to research on friendships in children with autism, Petrina et al. (2014) warn that determining the existence of a friendship is perhaps the biggest problem in the measurement of these relationships in children with

autism. The authors recommend collecting data from various sources—including the children, their nominated friends, their teachers, and their families—so that the information can be triangulated. They also note that only a few studies have analyzed the reciprocity of nominations received by children with autism and that the data collected from both members of the dyads are limited. This information is important for understanding whether the two perspectives coincide or are mismatched.

In cognitive social structures (CSS) designs (Krackhardt 1987), in contrast to designs involving peer nominations or social cognitive maps (Cairns and Cairns 1994), respondents report on the presence or absence of ties between each of the components of all possible dyads that make up the group. These designs could therefore be particularly useful in assessing the degree of agreement among children regarding the configuration of their friendship networks (Cappella et al. 2012). Since this approach provides information about all the children in a group, the answers can be triangulated among the informants in order to create a complete, consensus-based representation of the network (Brands 2013; Carley and Krackhardt 1996). This makes it possible to analyze the friendship relations on three levels: individual (self-reported), local (locally aggregated) and global (global aggregated). Thus, a friendship relation between A and B is considered to be reciprocal if both A says he is friends with B and B says he is friends with A (Petrina et al. 2017), but this relationship would be considered non-reciprocal at the global (global aggregated) level if more than 50% of participants do not report the presence of this relationship for one of the two parties (Neal 2008). Therefore, an imbalance in any of the three levels mentioned above results in asymmetrical friendships (Cappella et al. 2012). This sort of design can also be used to compare a child's individual perception with that of his classmates (Neal 2008). As indicated by Wasserman and Faust (1994), a CSS design provides much more information than traditional sociometric designs because “actors report not only on their own ties, but also on their perceptions of ties among all pairs of actors” (Wasserman and Faust 1994, p. 51).

Although the verbal and interactive behaviors of children with autism with their friends has been compared with these children's behaviors with their non-friends (i.e. friend vs. non-friend comparisons) (Bauminger et al. 2017; Bauminger and Agam 2014), we are unaware of any observational studies carried out in natural contexts that have incorporated the nuance of non-reciprocal friendships (i.e. friend vs. non-reciprocal friend vs. non-friend comparisons). The analysis of non-reciprocal friendship relations could help to improve our knowledge of the processes that contribute to the development of friendship relations between children with autism and their peers in a school context and facilitate the design

and planning of effective interventions to develop social skills in children with autism.

Berndt and McCandless (2009) note that friendships defined by non-reciprocated ties have real consequences and could play a key role in the regulation of social behavior, development and emotional balance (Hayes et al. 1980). Olsen et al. (2012) argue that non-symmetrical relationships could be an indicator with greater predictive power for social competence than reciprocal friendships. Moreover, non-symmetrical relationships could have an important effect on the effectiveness of peer influence (Almaatouq et al. 2016). As Carley and Krackhardt (1996) noted, “While symmetric friendships may be the ties that bind, non-symmetric friendships are the ties that build” (p. 24).

The Present Study

The main aim of the present study was to observe and analyze the social behavior of children with ASD interacting with their reciprocal friends, non-reciprocal friends, and non-friends during free play time at recess in order to identify possible differentiating patterns of interaction.

The combination of observational methodology and social network analysis can provide a method and tool for the multidimensional assessment of friendship that makes it possible to combine reports and self-reports on children's friendship relations with a more objective perspective on the interactions that take place in dyads. Specifically, this study applies a procedure for identifying the reciprocal and non-reciprocal friendships of children with autism in a school context, which allows the triangulation of information obtained from their peers.

Observational methodology combined with social network analysis of the group can: (a) facilitate the identification of peers who encourage the active engagement of children with autism (as opposed to peer selection in the traditional model of peer-mediated intervention); (b) provide information about the types of groupings (dyads, triads, small groups) that improve the frequency, duration, and quality of interaction with friends; (c) identify top-priority intervention objectives and the most appropriate methodology, techniques, and tools for achieving them; and (d) select activities that are mutually motivating and provide opportunities for children with autism and their friends to interact in a school setting.

Accuracy in social network perception is generally defined as the degree of similarity between an individual's perception of the structure of informal relationships in a given context and the real structure of these relationships. From a structural-cognitive perspective, differences in the perception of patterns of interaction have implications for individual results in a social group (Casciaro et al. 1999). We

have therefore adopted a dynamic perspective of knowledge, interaction, interpersonal relationships, and social structure in which structure affects knowledge and interaction while knowledge, in turn, modifies social structure.

Methods

Design

This is a single-case study that uses observational methodology with an idiographic, follow-up, multidimensional design (Anguera et al. 2001) and an ecological approach to compare patterns of social interaction between a child with autism and his reciprocal friends, non-reciprocal friends, and non-friends by means of polar coordinate analysis. Observational methodology is usually applied in combination with other data collection methods and in multiple designs, but it is most beneficial in studies carried out in natural contexts, as this maximizes ecological validity (Bakeman and Gnisci 2006; Volkmar 2011).

Participants

The participants were a student with high-functioning autism spectrum disorder (HFASD), aged 10 years and 3 months, and his 14 classmates (8 boys, 6 girls) from a third-grade elementary-education classroom. The classmates had the normative age for this grade (10 years) and none of them had autism. The student with HFASD, who was initially diagnosed with Asperger’s syndrome, has been enrolled in the same mainstream school since early childhood education. His composite score was 120 on the Wechsler Preschool and Primary Scale of Intelligence, 3rd edition (WPPSI-III), which places him at percentile 91; he also obtained an average-high score on the Peabody Picture Vocabulary Test (PPVT-III), which places him at percentile 55. The Childhood Autism Spectrum Test (CAST; Scott et al. 2002) indicated that he had difficulties with peer relationships, rarely approached other children to play, did not consider it important to fit in with his peer group, and generally did not show the same interests as his peers.

The boy with HFASD went to a public school attended by around 300 students in pre-school and elementary education, of whom 30% were Roma and 15% were immigrants. Systematic observation and recording were carried out in the schoolyard during recess. Only the CSS procedure was applied in the regular classroom. During recess, students went out to the playground area assigned to them. This area, enclosed by the school building, measured 60 m by 45 m and consisted of several spaces that were clearly differentiated by the type of surface and the presence of various resources: a multi-purpose sports field, a sandy area with vegetation composed of trees and hedges, and a paved area.

Measures

Cognitive Social Structure

The CSS design (Krackhardt 1987) is an extension of the traditional sociometric procedures that includes the actors’ perceptions of the network (Wasserman and Faust 1994) and provides a flexible method for assessing individual accuracy in terms of the relationships that occur in a group (Brands 2013; Krackhardt 1987). A CSS network involving N individuals is usually represented by a three-dimensional array $R_{i,j,k}$ ($i, j, k = 1, \dots, N$), where i is the sender, j is the receiver, and k is the perceiver of the relationship (Krackhardt 1987).

An actor’s network perception matrix is referred to as a CSS slice; thus, it indicates all ties between i and j , holding the perceiver constant. Indications of perceiver responses for the two members of any dyad are referred to as locally aggregated structures. Information provided by every individual’s perception of the tie between i and j in the network is referred to as a global aggregated structure. The inconsistencies that can occur are represented graphically in Fig. 1; thus, for any dyad, there are 16 possible results.

Non-confirmation reflects a disagreement between the parties about the existence or non-existence of a friendship relation between i and j or vice versa. Relationships of this type are especially important because they show that one party’s perception does not conform to the information provided by the other party (Carley and Krackhardt 1996). Non-symmetries occur when an informant perceives an

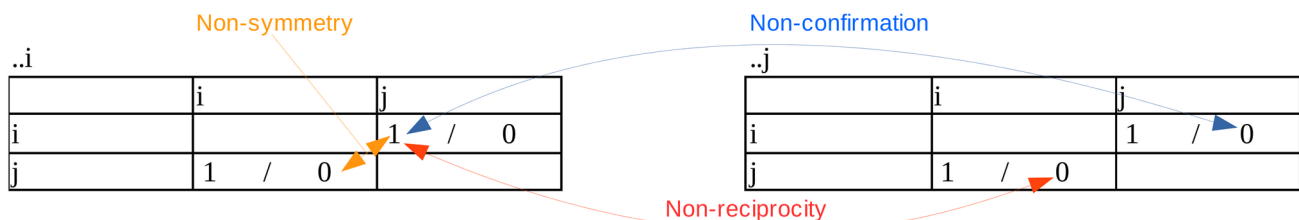


Fig. 1 Possible cognitive inconsistencies in the perception of friendship relations

inconsistency in his belief that the relationship is reciprocal. Inconsistencies of this type reflect an awareness that the friendship is not reciprocated by the other party. Certain capacities of interpersonal perception and social comparison are necessary in order to make this sort of judgment; in light of the theory of the mind, it is possible that these capacities are not present in students with autism (Baron-Cohen 2008).

Locally aggregated structures reflected the self-reported relationships of the participating classmates. A reciprocal friendship was considered to be present between two children, A and B, when A reported a friendship relation with B and B also reported a friendship relation with A. A global aggregated structure reflected an “inferred” relationship between two children, A and B, when more than 50% of these children’s participating peers reported that they had a friendship relation. It was possible to calculate measures of degree, betweenness, reciprocity, density, and closeness centrality for individual, locally aggregated, and global aggregated CSS slices.

Observation of Social Interaction During Recess

We designed an ad hoc observation instrument, initially consisting of a system of categories for each dimension. The selected categories were defined and delimited in accordance with the reality observed during the exploratory phase of the study. New dimensions were subsequently added and the final result was an instrument that combined a field format and category system (Anguera 2003).

The coding system included the following five interactive states (*adult*, A; *low-intensity social interaction*, L; *joint engagement*, J; *inadequate interaction*, N; and *solitary*, S); three discrete behaviors (*initiation* of social interaction, i; *response* to a social interaction, r; *challenging* interactions, d), and a numerical code for each peer with whom the target child interacted on the playground (1–n). The codes for this last dimension were subsequently molarized and grouped according to the type of relationship between the child with autism and each of his classmates, which was obtained using a self-reported social network structure (reciprocal friend, non-reciprocal friend, non-friend). This instrument, developed after an initial exploratory phase, incorporated codes and definitions from proposals such as the Behavior Coding Scheme (BCS; Hauck et al. 1995) and Playground Observation of Peer Engagement (POPE; Kasari et al. 2012). Table 1 shows the dimensions, category systems, and codes, as well as their definitions, which were recorded from the beginning to the end of the session.

Trained undergraduate research assistants coded interaction sequences using jWatcher (v.1.0) (Blumstein et al. 2007). This software package makes it possible to record, in real time, specific behaviors (e.g. responding to or initiating an interaction) and actions that extend over time (e.g. being alone, interacting adequately). Each observation consisted of 10 min of continuous in vivo recording in a naturalistic, unstructured context at recess time.

Table 1 Dimensions, categories, codes, and definitions for observation social interaction during recess

Dimensions	Category systems (<i>codes</i>)	Definition
Interaction states	Adult (A)	The student interacts with teachers or caregivers
	Low-intensity interaction (L)	Proximity without communicative intention. The student remains next to or closely follows (< 1.5 m) a classmate or group of classmates, either without participating in a particular activity or as a mere observer
	Joint engagement (J)	The student participates actively in an activity with one or more classmates. They share a game, collaborate in an activity, talk, laugh, etc
	Inadequate interaction (N)	The student shows hostility or anger toward one or more classmates while participating in an activity
	Solitary (S)	The student is alone, without doing any activity or he performs some activity at a distance of more than 1.50 m from his classmates
Communicative acts	Initiates an interaction (i)	The student adequately starts a verbal, non-verbal, or mixed social interaction with one or more classmates; it is distinguished from the continuation of the prior social sequence because it involves a change in the recipient (in a group, he is talking to one classmate and then addresses a different one; or there is a change in the activity or in the reference)
	Responds to interaction (r)	The student responds adequately to a direct verbal or non-verbal interaction of one or more classmates, which is distinguished from the continuation of the previous social sequence by a change in the classmates to whom he responds or in the activity. There is a clear communicative intention
	Challenging interaction (ch)	The student initiates or responds inappropriately to an interaction with one or more of his classmates
Partners	1–14 15–n	Peers with whom target child interacted, including his classmates (1–14) as well as other children with whom he interacts during recess (15–n)

Procedure

After obtaining permission from the school and the educational authorities, as well as the informed consent of the families (parent letters and consent forms were sent home), we began the systematic observation. More than 1000 min—spread over 50 sessions lasting an average of 10 min each—were recorded. The recordings were carried out entirely at recess time. To ensure homogeneity between observation sessions, the recording started each day at 12:20 p.m. and concluded at the sound of the bell that signaled the end of recess. Observations were carried out every day of the week unless the focal student was absent or the students did not go out at recess time. All sessions were simultaneously recorded by two observers from beginning to end, without interruption. The two observers remained at a distance of approximately 3–6 m from the student so that they could accurately record his activity and comments. When he was alone and far from his classmates, the observers increased their distance to avoid excessive focus and possible stigmatization of the student.

The CSS procedure was administered during school hours; two research assistants were present to assist students with the survey items. Each child in the group was given an individual questionnaire that included a page about each classmate, including themselves. Each page of the questionnaire included a class list and the child was asked to circle the names of the students he or she thought were friends with the classmate featured on that page. The questionnaires, which were constructed using the class list, were used to collect both the participants' self-reports on their friendships as well as inferences about the friendships of their classmates, using the model proposed by Neal and Kornbluh (2016). This method is more accurate than methods based on peer nominations, since it allows the triangulation of information obtained through self-reports and peer reports (Wasserman and Faust 1994). The children were allowed to complete the questionnaires at their own pace; completion took approximately 25–30 min.

Data Analysis

Social Network Analysis

Each child provided a complete matrix of how he or she perceived friendship relations within the classroom. Indegrees were coded as the total number of received friendship nominations (the number of classmates that listed the child as “has a friendship relation with...”) whereas outdegrees were coded as the total number of outward friendship nominations by the child (the number of classmates the child listed as “has a friendship relation with...”).

The cohesion indicators provided by the social network analysis were analyzed in order to identify the structural properties of the classroom network. To evaluate the existence of associations between the matrix of friendship relations generated by the focal student and the network of friendships generated by consensus of a majority of participants (global aggregated structure), we applied the quadratic assignment procedure (QAP), which compares adjacency matrices using a nonparametric permutation test between the pairs that make up the network (Krackhardt 1988). As for the magnitude of the QAP correlation, following Kwon and Lease (2014), we considered that values between .1 and .3 indicate a small correlation, values between .3 and .5 indicate a moderate correlation, and values above .5 indicate a high correlation.

Lag Sequential Analysis

The general analysis strategy was implemented in two stages. The first stage—global, descriptive, and synchronic—allowed us to obtain overall descriptive measures, taking into account the co-occurrences of behaviors at each response level. Lag sequential analysis was used to investigate temporal relationships between discrete behaviors (events) and interactive states with friends, non-reciprocal friends, and non-friends. This technique makes it possible to identify temporal patterns and associations between the observed behaviors and reveals the possible associations between these behaviors through the calculation of observed and expected probabilities (Bakeman and Quera 2011), and it has been used in previous studies on autism (Bottema-Beutel et al. 2017; Vernon 2014; Warreyn et al. 2007).

The second stage of analysis—microanalytical and diachronic—consisted in the application of the lag sequential analysis and polar coordinate analysis techniques to detect regularities in the sequence of behaviors. The search for associations between the focal behavior and conditional behaviors was both prospective (lags of 1, 2, 3, 4, and 5) and retrospective (lags of -1, -2, -3, -4, and -5). To carry out this analysis, the data recorded with jWatcher (Blumstein et al. 2007) were transferred to the SDIS-GSEQ software package, v. 5.1 (Bakeman and Quera 2011).

We used the polar coordinates technique (Cochran 1954) to compare the social interactions of the target student with HFASD with friends, non-reciprocal friends, and non-friends. This technique—applied by Sackett (1980) and later optimized with the genuine retrospectivity technique proposed by Anguera (1997)—allows data reduction by using the Z_{sum} statistic ($Z_{\text{sum}} = \Sigma z / \sqrt{n}$), where Z represents the independent values obtained from the adjusted residuals found for the respective lags of -5 to -1 and 1 to 5, with n as the number of lags. Z_{sum} values therefore make it possible to estimate the type of relationships that can be established

between the focal behavior and all other behaviors included in the observation instrument (conditional behaviors).

To carry out this analysis, we used HOISAN v. 1.6 (Hernández-Mendo et al. 2012), a software package that makes it possible to work with all the data types proposed by Bakeman and Quera (2011): single-code event, timed event, state, interval, and multi-code event. The program supports the sharing of data with specific programs used in observational methodology, such as SDIS–GSEQ. This technique has previously been applied in research on the social interaction of people with autism (Canal and Rivière 1993) as well as on interaction in school settings (Santoyo et al. 2017).

Odds Ratio (OR)

An OR is a measure of sequential association that controls for base rates of the behaviors of interest and the duration of the time probes (Bakeman and Quera 2011; Yoder and Tapp 2004). The final odds ratio calculation yields a measure of effect size. A general guideline suggested by Bakeman and Quera (2011) is that odds ratios over 3.0 indicate strong relationships, those between 1.25 and 2.00 indicate weak relationships, and those between 2.00 and 3.00 indicate moderate relationships.

Interobserver Agreement

Trained undergraduate research assistants served as data collectors. The observers first read and collectively reviewed a coding manual for this project. Observers achieved 90% reliability in 12 in vivo sessions at school recess. Interobserver agreement (IOA) was collected for 64.3% of the sessions. To ensure the reliability of the observations of each behavior, we used Cohen's kappa statistic (Cohen 1988) to calculate the agreement of the data obtained by the two observers in GSEQ5 (version 5.1). Following the recommendations of Bakeman and Quera (2011), taking into account that values for time-unit kappa with tolerance vary slightly depending on which of the two observers is considered first, this value was calculated twice, alternating the order of the observers. A tolerance of two time units was allowed, resulting in a time window of 5 s (the present unit, the two previous units, and the two subsequent units) (Bakeman and Quera 2011). According to the scale proposed by Landis and Koch (1977), values below .40 represent low reliability, values between .41 and .80 represent moderate to good reliability, and values above .81 are considered excellent reliability. The resulting kappa statistic was .86 [.86 – .87] for interaction states and .87 [.87 – .87] for the communicative acts dimension, which guarantees the interpretive rigor of the coding process. In order to guarantee the rigor of the dataset and control for possible biases, the observers were blinded to the type of

friendship relation that linked the child with autism to his classmates. Therefore, the observers recorded the identity of each peer with whom the child with autism interacted and possible errors were revised immediately after each session. As a result, agreement was 100% for this dimension.

Results

We first report the results of the descriptive analyses for the boy with autism and the peer group on measures of cognitive social structure of friendship, social network structure, and friendship nominations (indegrees, outdegrees, and reciprocity). We then report the descriptive data for the playground observations of the boy with ASD and lag sequential analysis of his interactions with friends, non-reciprocal friends, and non-friends. Finally, we report differences in interaction patterns as a function of type of relationship.

Friendship Network

The number of friendship relations within the group identified by the participants ranged from 35 (focal student) ($N = 15$, $M = 2.33$, $SD = 1.11$, range 1–5) to 188 (girl 14) ($N = 15$, $M = 12.53$, $SD = 2.38$, range 7–14). Outdegree values for the target student with ASD were significantly lower than the mean outdegrees for the group at the specified .05 level ($t(14) = -16$, $p < .01$, 95% CI [-5.21, -3.98]). Students received 6.93 friendship nominations on average ($N = 15$, $SD = 2.9$, range 1–14), while the target student received 5.8 friendship nominations on average ($N = 15$, $SD = 4.06$, range 1–14). In general, individual children displayed a moderate level of agreement with their peers on friendship social network (Jaccard = .58, QAP value = .55, $p < .01$). QAP correlation analysis revealed that the boy with autism exhibited lower levels of agreement with the consensus (global aggregation) (Jaccard = .33, QAP value = .24, $p < .01$) than the least central actor (girl 9) (Jaccard = .51, QAP value = .57, $p < .01$).

Density (D) has been defined as the number of ties divided by the total possible number of ties as an indicator of cohesion. To compare densities among the friendship social network perceived by the boy with autism, the true network (local aggregation), and the consensus structure (global aggregation), we used the compare-densities bootstrapping test in UCINET (Borgatti et al. 2002). The network density perceived by the boy with autism ($D = .17$, $SE = .0324$) was significantly lower than that of the true network ($D = .66$, $SE = .0645$) and that of the consensus structure ($D = .45$, $SE = .0578$).

Taking into account the locally aggregated structure matrix (self-reported network), the children identified 139 links of friendship overall, 102 of which were symmetrical,

with 51 of the dyads representing reciprocal friendships, 37 representing non-reciprocal friendships, and 17 representing non-friendships. The percentage of reciprocity was therefore 58%. The child respondents reported non-reciprocal friendship relations for an average of 19.58% of the dyads in the class ($SD = 4.46$, range 9.69–32.59%), whereas the boy with autism reported asymmetrical relationships for an average of 9.5% of the dyads in the class ($SD = 6.23$, range 0–23.55%).

Communicative Acts by Type of Relationship

The focal student exhibited difficulties initiating social interactions with his peers mainly when he was alone. Sometimes he approached or followed a classmate or group of classmates without addressing them directly and without any apparent communicative intention. He did not usually initiate interactions when his classmates were playing games that he did not like. Table 2 presents the ORs of initiation and response to social interactions, challenging behaviors and interactive states by type of friendship relation.

Although the frequency of social initiations targeting friends (OR 4.01, 95% CI [2.17, 7.40]) was significantly higher than that of social initiations targeting non-reciprocal friends (OR 0.51, 95% CI [0.17, 1.52]) and non-friends (OR 1.77, 95% CI [0.98, 3.18]), for responses to interactions this tendency was inverted. Thus, a strong association was observed between the responses to the social interactions of non-reciprocal friends (OR 8.8, 95% CI [3.24, 23.91]) and the responses to interactions of non-friends (OR 3.82, 95% CI [2.23, 6.54]), while no significant relationship was observed in the responses to reciprocal friends (OR 1.27, 95% CI [0.73, 2.22]). Meanwhile, a strong association was found between challenging behaviors and interactions with friends (OR 3.25, 95% CI [1.17, 9.05]), whereas this relationship was not significant for non-reciprocal friends (OR 0.53, 95% CI [0.07, 4.17]) or non-friends (OR 1.66, 95% CI [0.60, 4.62]).

However, we observed that, given a state of *joint engagement*, the likelihood of *initiating an interaction with a*

non-reciprocal friend was significantly higher than chance ($z = 2.28$, $p = .02$), whereas this was not true for *initiation of interactions with reciprocal friends* or with *non-friends* ($z = .63$, $p = .54$; $z = 1.42$, $p = .16$; respectively) at the specified .05 level.

We also observed a strong relationship in the frequency of *responses to non-reciprocal friends* given a state of *active engagement* (OR 3.16, 95% CI [1.31, 7.16]) and a moderate relationship in *responses to non-friends* (OR 2.4, 95% CI [1.37, 4.19]), in contrast to a weak relationship in *responses to reciprocal friends* (OR 1.30, 95% CI [0.63, 2.66]) given this same state.

Polar Coordinate Analysis

The graphs in Fig. 2 show significant associations between the focal and conditional behaviors. Clear differences between the three relationship types can be observed. While the focal behaviors *initiation of interaction with a reciprocal friend* and with a *non-friend* had a mutually inhibitory effect on the conditional behavior *adult* (A) (Quadrant III, radius = 3.08, $p < .05$; Quadrant III, radius = 2.33, $p < .05$; respectively), we identified a mutually excitatory relationship between *initiation of interaction with a non-reciprocal friend* and the conditional behavior *joint engagement* (Quadrant I, radius = 4.48, $p < .05$) and a significantly inhibitory effect on the conditional behavior *solitary* (S), which, in turn, activated this focal behavior (Quadrant II, radius = 2.08, $p < .05$) and did not occur with any other focal behaviors.

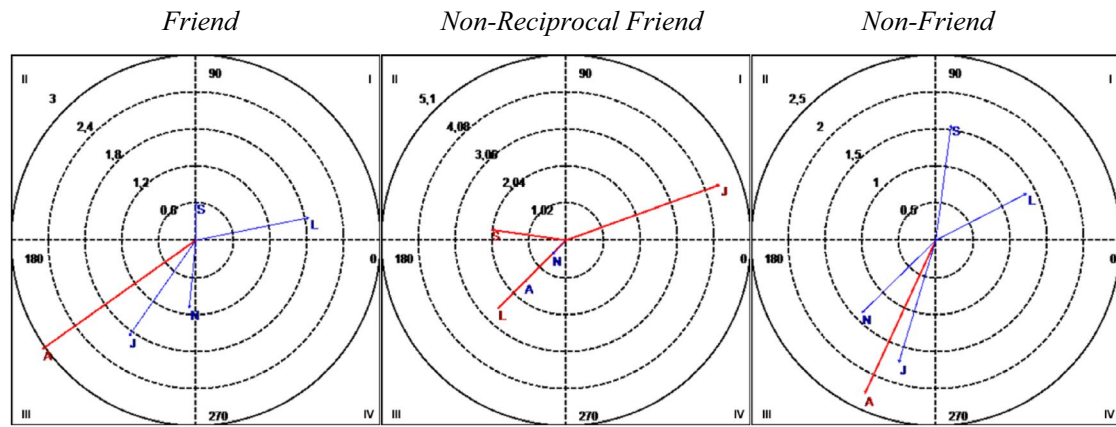
A similar effect was observed in the case of *responses to interactions* being taken as focal behaviors as a function of relationship type (Fig. 3). No mutually excitatory relationship was observed between the conditional behaviors and the focal behavior *response to a reciprocal friend*, although such a relationship was observed between the focal behaviors *non-reciprocal friends* and *non-friends* and the conditional behavior *joint engagement* (J) (Quadrant I, radius = 5.48, $p < .05$; Quadrant I,

Table 2 Odds ratios of social interaction behaviors and interactive states by type of friendship relation

	Reciprocal friend		Non-reciprocal friend		Non-friend	
	OR	95% CI	OR	95% CI	OR	95% CI
Initiations	4.01	(2.17–7.40)*	0.51	(0.17–1.52)	1.77	(0.98–3.18)
Responses	1.27	(0.73–2.22)	8.8	(3.24–23.91)*	3.82	(2.23–6.54)*
Challenging behaviors	3.25	(1.17–9.05)*	0.53	(0.07–4.17)	1.66	(0.60–4.62)
Adult	0.50	0.14–1.78	0.91	(0.20–4.12)	0.88	(0.33–2.37)
Low-intensity	2.69	(1.35–5.36)*	0	–	0.70	(0.33–1.46)
Active engagement	0.75	(0.43–1.30)	3.31	(1.36–8.03)*	1.62	(0.97–2.73)
Solitary	0.62	(0.30–1.28)	0.71	(0.26–1.95)	0.64	(0.34–1.24)

Negative interactions were removed due to the low frequency of this type of interaction

*Significant relationships ($p < .05$) between the focal behavior and conditional behavior



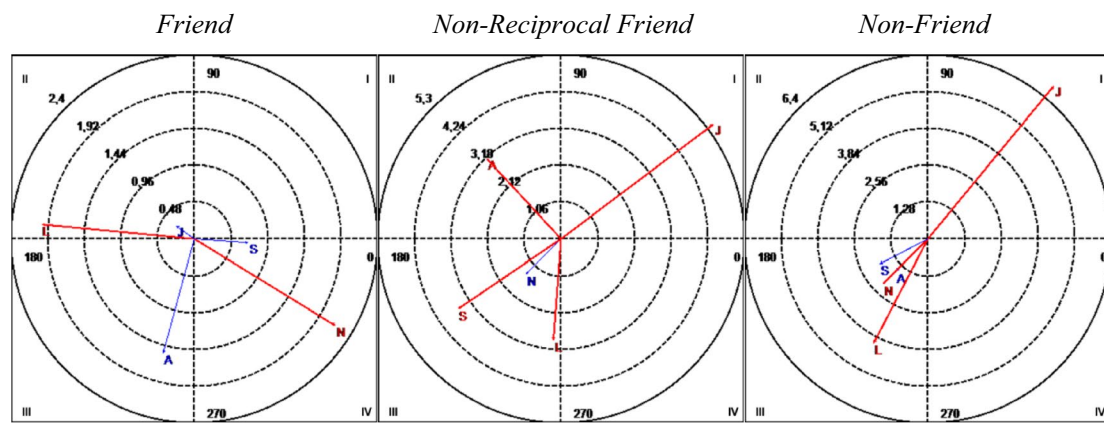
Friend						
State (code)	Quadrant	Prospective perspective	Retrospective perspective	Ratio	Radius	Angle
Adult (A)	III	-2.52	-1.78	-0.58	3.08 (*)	215.23
Low-Intensity (L)	I	1.86	0.37	0.2	1.89	11.37
Joint Engagement (J)	III	-1.1	-1.57	-0.82	1.92	235.04
Negative Interaction (N)	III	-0.11	-1.12	-1	1.12	264.49
Solitary (S)	II	0	0.61	1	0.61	90.34
Non-Reciprocal Friend						
Adult (A)	III	-1.15	-1.15	-0.71	1.62	225
Low-Intensity (L)	III	-1.88	-1.88	-0.71	2.66 (*)	225
Joint Engagement (J)	I	4.22	1.52	0.34	4.48 (*)	19.75
Negative Interaction (N)	III	-0.39	-0.39	-0.71	0.56	225
Solitary (S)	II	-2.06	0.29	0.14	2.08 (*)	171.88
Non-Friend						
Adult (A)	III	-0.98	-2.11	-0.91	2.33 (*)	245.1
Low-Intensity (L)	I	1.25	0.64	0.45	1.41	27
Joint Engagement (J)	III	-0.51	-1.68	-0.96	1.75	253.21
Negative Interaction (N)	III	-1.02	-1	-0.7	1.43	224.47
Solitary (S)	I	0.21	1.58	0.99	1.59	82.54

*Significant relationships ($p < .05$) between the focal behavior and conditional behaviors

Fig. 2 Polar coordinate analysis results for social initiations by the student with high-functioning autism spectrum disorder toward his peers as the focal behavior and the state categories as conditional behaviors

radius = 6.95, $p < .05$; respectively). A mutually inhibitory effect was also found between *responses to non-reciprocal friends* and the conditional behaviors *solitary* (S) (Quadrant III, radius = 3.58, $p < .05$) and *low-intensity* (L) (Quadrant III, radius = 2.92, $p < .05$). In contrast, *responses to friends* had a significant inhibitory effect

on the focal behavior *low-intensity* (L), which, in turn, had an excitatory effect on these responses (Quadrant II, radius = 2.02, $p < .05$).



Friend						
State (code)	Quadrant	Prospective perspective	Retrospective perspective	Ratio	Radius	Angle
Adult (A)	III	-0.41	-1.5	-0.96	1.55	254.68
Low-Intensity (L)	II	-2.01	0.19	0.09	2.02 (*)	174.74
Active Engagement (J)	II	-0.24	0.17	0.58	0.29	144.26
Negative Interaction (N)	IV	1.86	-1.14	-0.52	2.18 (*)	328.48
Solitary (S)	IV	0.71	-0.05	-0.08	0.71	355.65
Non-Reciprocal Friend						
Adult (A)	II	-2.13	2.29	0.73	3.12 (*)	132.9
Low-Intensity (L)	III	-0.22	-2.91	-1	2.92 (*)	265.69
Active Engagement (J)	I	4.38	3.28	0.6	5.48 (*)	36.81
Negative Interaction (N)	III	-1.01	-1.01	-0.71	1.42	225
Solitary (S)	III	-2.96	-2.01	-0.56	3.58 (*)	214.23
Non-Friend						
Adult (A)	III	-1.13	-1.14	-0.71	1.61	225.09
Low-Intensity (L)	III	-1.91	-3.66	-0.89	4.13 (*)	242.43
Active Engagement (J)	I	4.43	5.36	0.77	6.95 (*)	50.41
Negative Interaction (N)	III	-1.58	-1.58	-0.71	2.24 (*)	225
Solitary (S)	III	-1.69	-0.88	-0.46	1.91	207.35

*Significant relationships ($p < .05$) between the focal behavior and conditional behaviors

Fig. 3 Polar coordinate analysis results for social responses by the student with high-functioning autism spectrum disorder toward his peers as the focal behavior and the state categories as conditional behaviors

Discussion

Although reciprocity has been considered an essential property of friendship (Bukowski et al. 2009), it is not possible to apply this ideal to all relationships described as friendships,

since in many cases the exchanges between the members of friendship dyads can be characterized by an imbalance in reciprocity (Almaatouq et al. 2016; Carley and Krackhardt 1996). This sort of unilateral friendship has been viewed as an expression of a desire for friendship, rather than an actual

consolidated relationship (Laghi et al. 2014). Consequently, this type of relationship has often been excluded from subsequent analyses, thus leading to a reduction in sample size, representativeness, and, consequently, the statistical power to test hypotheses, since these children are unlikely to be excluded randomly (Berndt and McCandless 2009), giving rise to the possibility of information distortion (Olsen et al. 2012).

Although the boy with autism exhibited high awareness of who his reciprocal friends were—as confirmed by these friends individually (locally aggregated structure) and by the group as a whole (consensus structure)—some of the reciprocal friendships expressed by the boy and by his peers (self-reported) were perceived by the group as non-reciprocal friendships or non-friendships (consensus structure). Consistent with previous findings, we found little relationship between reciprocal nominations received by the student and real social interaction in playground systematic observation (Kasari et al. 2011). We also found little relationship between the locally aggregated structure (self-reported or “true” network) and the global aggregated structure (consensus structure) and observed a stronger relationship between the consensus structure and the observational records. For the classmates, accurately identifying the friendship relations of the child with autism was more difficult than identifying the friendships of the other children in the group, including newcomers. These differences in the processing of social information and interpersonal perceptions affected the child with autism as both a judge and a target in a two-way process that could lead children with autism and their peers to under-report the number of potential friends.

Mendelson et al. (2016) noted that differences in social information processing speed can affect the processes involved in friendship development. Specifically, they found that slower social information processing leaves children with ASD more dependent on specific feedback than typically developing children, which can make them difficult playmates and is likely to have an effect on the reciprocity of their friendships. Rotheram-Fuller et al. (2010) found that children with ASD had misperceptions regarding their friendship relations, given that they nominated as friends other children who did not consider the children with ASD as belonging to their group. They noted, however, that it is unclear whether this mismatch arises from these children’s difficulties in understanding friendship or from an inability to assess the reciprocity of their relationships.

The accurate identification by the boy with autism of some of his non-reciprocal friendship relations as well as those of his peers, confirmed both by the peers and by the group as a whole, indicates that he understood when friendship was not reciprocated by the other party—an awareness that requires certain capacities of self-assessment and social comparison. However, given the boy’s identification of a

significantly lower number of friendship relations than his peers, the poor agreement between the network of friends perceived by the boy and that perceived by his peers, and the low cohesion of the network perceived by the boy, we believe it is possible that the boy’s perception of friendship relations was influenced more by behavioral markers (such as physical proximity) or the presence of common demographic characteristics (gender, origin, ethnicity) than by the affective components of these relationships (affective closeness or proximity, affective sharing), thus confirming the results of other studies that point in this direction (Bauminger and Kasari 2000; Chamberlain et al. 2007; Mendelson et al. 2016). Moreover, these findings support the conclusions of Calder et al. (2013), who found that children with autism have a different understanding of friendship that might be centered more on company than on shared emotions or feelings, and that they might enjoy friendship relations with a lower degree of affective bonding.

We found that the boy’s likelihood of responding to non-reciprocal friends was significantly greater than his likelihood of responding to friends, and that his responses to non-reciprocal friends and non-friends alike activated joint engagement, whereas responses to friends did not. These results, which are partially consistent with previous findings, highlight the significant friend versus non-friend differences in the frequency and variety of speech acts (Bauminger et al. 2017). Although non-friend and non-reciprocal friend interactions may be a factor of stress and anxiety and may pose a higher social challenge for children with HFASD than interactions with friends, it is possible that this stress and anxiety could decrease as the relationship develops (McMahon et al. 2013). These results suggest the possibility that interactions with non-reciprocal friends could also entail greater motivation on the part of at least one party, thanks to the desire to establish a friendship relation, and that this sort of interaction could satisfy similar needs to reciprocal friendships in children with autism.

Conclusions, Limitations, and Future Directions

Asymmetrical friendship relations, although apparently a constant factor in children’s interpersonal relationships, have often been excluded from analysis in research (Olsen et al. 2012). The data suggest that systematic observation and a detailed analysis of non-reciprocal friendship relations in children with autism could help to expand our knowledge of the processes that contribute to friendship development and of these children’s perception of the concept of friendship.

To the best of our knowledge, this is the first study to compare interpersonal perceptions and patterns of social interaction between a school-age boy with autism and his

reciprocal friends, non-reciprocal friends, and non-friends. Our findings have confirmed the results of previous research on patterns of interaction with friends and identified clear differences in the perception of friendship relations between the boy with autism and his classmates. These findings open up the possibility of studying the interpersonal perceptions and friendship relations of children with autism in natural school settings from an ecological perspective that combines the rigor of observational methodology with the flexibility of social network analysis.

However, the results should be interpreted with caution, as this exploratory study was only implemented in a single group. Therefore, we obviously do not intend for our results to be generalizable, especially considering the heterogeneity of the quantity, quality, and nature of friendship relations in children with autism (Calder et al. 2013; Mendelson et al. 2016). These results need to be verified with a larger number of participants in different grades and schools. We also recommended the observation of the possible evolution of friendship networks from the beginning of a new school year.

This study has also uncovered several issues that could be investigated in future research. Future studies should control for factors such as the directionality of friendship ties and the extent to which it affects the behavior of both children with autism and their peers. It would also be interesting to study how other variables such as grade, class size, gender, and perceived popularity affect the accuracy of perceptions of friendship relations (Neal et al. 2016). Some previous studies have shown that regardless of centrality in social network structure, self-perceived position has a significant impact on actors' outcomes (Kilduff and Krackhardt 2008).

The results of this study could have implications for intervention objectives and the design of support initiatives aimed at improving the interpersonal relationships of children with ASD in public schools. Specifically, polar coordinate analysis makes it possible to compare the social behavior of a child with autism in interaction with friends, non-reciprocal friends, and non-friends in different focal states (e.g. the child was previously alone, he was previously with an adult, the interaction was low-intensity, etc.). This procedure could facilitate the selection and training of the peers chosen to take part in evidence-based practices such as peer-mediated instruction and intervention, while also helping to identify the top-priority objectives of the intervention (Locke et al. 2017).

We consider that this proposal can help to further our knowledge of the processes that contribute to friendship development between children with autism and their peers in mainstream school settings. Moreover, it can help teachers apply research-based practices to improve social relationships in students with HFASD in inclusive school environments and can also benefit the rest of the students with

whom the students with HFASD interact. Due to the unique characteristics of the friendship relations of children with autism, a set of specific methods and measures is needed to study the characteristics and functions of friendship relations and their effects in these children.

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Author Contributions JR-M conceived, designed and led the study, performed the measurement, analysis, interpretation of the data and drafted the manuscript. HR-N contributed to the study conception and design, and participated in drafting the manuscript. VA designed the study, and participated in analysis and interpretation of the data. BA contributed to the study design and performed the measurement, analysis, and interpretation of the data. MTA contributed to the study design, coordinated analysis and interpretation of the data, and helped to draft the manuscript. All authors approved the final manuscript as submitted.

Compliance with Ethical Standards

Conflict of interest The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest. All authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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