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# The Social Networks of Children With and Without Disabilities in Early Childhood Special Education Classrooms

**Jing Chen[1] · Tzu-Jung Lin[1] · Laura Justice[1,3] · Brook Sawyer[2]**



**Abstract** Interaction with peers is an important contributor to young children's social and cognitive development. Yet, little is known about the nature of social networks within preschool inclusive classrooms. The current study applied a social network analysis to characterize children's peer interactions in inclusive classrooms and their relations with children's disability status. The participants were 485 preschoolers from 64 early childhood special education (ECSE) inclusive classrooms. Results from teachers' report of children's social networks showed that children with disabilities formed smaller play networks compared to their typically developing peers in the classroom, but no evidence indicated that children with disabilities engaged in more conflict networks than their counterparts. Children's play and conflict networks were segregated by children's disability status.

**Keywords** Inclusive preschool classrooms · Peer interaction · Disability status · Exponential random graph models (ERGMs)

## Introduction

Young children's interactions with peers provide them with critical opportunities to foster their social and cognitive development, and this is true for both typically developing children (e.g., Brechwald and Prinstein 2011) as well as children with disabilities (e.g., Humphrey and Symes 2011; Raghavendra et al. 2012). Within early childhood settings, research has shown that children are influenced by the skills of their peers, and that important benefits can be derived from providing children with disabilities the opportunity to interact regularly with typically developing children (Justice et al. 2014). To this end, there has been a longstanding emphasis in early childhood programming to provide children with disabilities with the opportunity to interact with typically developing peers within the context of early childhood special education (ECSE) inclusive classrooms. Paradoxically, studies suggest that children with disabilities are likely to be socially segregated by peers in inclusive settings (Hanson et al. 1997; Luciano and Savage 2007), although the large-scale study of this phenomenon in ECSE settings has yet to occur.

To contribute to this important area of study, in the present study we examined peer interactions within ECSE inclusive classrooms using a social network analysis approach. The overarching goal of the study was to illustrate the social networks experienced by both children with disabilities and their typically developing peers in these inclusive classrooms. For the purpose of this study, a social network is defined as a set of play or conflict interactions formed by

✉ Jing Chen
chen.4046@osu.edu

Tzu-Jung Lin
lin.1653@osu.edu

Laura Justice
justice.57@osu.edu

Brook Sawyer
lbs211@lehigh.edu

[1] Department of Educational Studies, The Ohio State University, Columbus, OH 43210, USA

[2] College of Education, Lehigh University, Bethlehem, PA 18015, USA

[3] Crane Center for Early Childhood Research and Policy, Columbus, OH 43201, USA

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children with and without disabilities within a classroom; this term is used interchangeably with peer interactions.

### Social Networks of Preschool Children With and Without Disabilities

Interaction with peers is essential to human development, as supported by prevalent developmental theories and an abundance of research. To the former point, Bandura's (1971) social learning theory suggests that observation and imitation of peers serve as key mechanisms through which children learn from peers, whereas Vygotsky's (1978) sociocultural theory proposes that learning and development occur within social activities wherein children co-construct their cognitive and social knowledge together with their peers. Importantly, the influence of peers on the development of young children begins as early as the preschool period, when children gradually transit from the home to classroom social environments (Rubin et al. 1998) and begin to acquire more complex interactive behaviors (Piker and Rex 2008). Today, with a majority of young children attending center-based preschool programs by age four in the United States, early childhood classrooms provide a critical environment in which children have the opportunity to interact with and learn from their peers.

Peer interaction is associated with various dimensions of children's early development within preschool classroom contexts. For instance, Stanton-Chapman et al. (2008) found that Head Start children with high risks of language and social problems improved their social communication skills (e.g., turn taking) when provided with play-based social interaction opportunities, incidental language, and social support. In the area of language development, Lin et al. (2016) found that preschool children select peers to interact regularly in the classroom on the basis of similarity in skill levels. Interestingly, such work also showed that over time, preschool children become even more similar in skills to those with whom they interact as compared to those with whom they do not.

Given the importance of peer interaction, especially as a potential mechanism for their learning and development, federal education policies have required that children with disabilities have the opportunity to study alongside their typically developing peers in the least restrictive environment (LRE) (Lowe et al. 2008). For preschoolers with disabilities, the LRE is often actualized as placement within an inclusive setting, in which both children with disabilities and children who are typically developing are enrolled. Inclusive education aims to provide equal opportunities and educational resources for children with and without disabilities and to promote the independence and social engagement of children with disabilities with peers (Eriksson et al. 2007). Given these purposes, it stands to reason that the degree of social engagement that children experience in inclusive classrooms will have significant influences on their health, personal well-being, and academic outcomes, and serves as an important mechanism for the value and effects of the LRE paradigm.

Nonetheless, the effectiveness of inclusive education in facilitating positive social interaction among young children with and without disabilities is still debatable (Locke et al. 2013). Some research suggests that inclusive placements could increase the risk of isolation and rejection for children with disabilities (Chamberlain et al. 2007; Luciano and Savage 2007), hindering their perception about school (Eriksson et al. 2007), and increasing their chances of being victims of bullying (Luciano and Savage 2007; Mishna 2003). On the contrary, inclusive education may be able to strengthen learning and development for both children with and without disabilities if children are given opportunities to build higher self-expectations, receive individualized support, learn from age-appropriate models and interactional partners, and experience collaboration and teamwork (Chamberlain et al. 2007; Downing and Peckham-Hardin 2007; Hestenes and Carroll 2000). Being in a positive and caring environment, Rafferty et al. (2003) found that children with severe disabilities performed better in language development and social skills in inclusive classrooms than their counterparts in segregated classrooms.

In this study, we conceptualize children's peer interactions in ECSE inclusive classrooms as social networks in which children with and without disabilities play or have conflicts with each other. Research on children's play-based social networks, or play networks, shows that children begin to establish preferences for particular peers as early as toddlerhood. Even very young children have preferences towards playmates (Strayer 1980). Investigation of play networks is important within the preschool context, since the ability to interact with peers through play is a predominant way through which children develop language, social, and cognitive skills (e.g., Howes et al. 1988; Lillard et al. 2013; Parten 1932; Stanton-Chapman and Hadden 2011). When playing with peers interactively, children have opportunities to share meaning, regulate emotion, and exercise reciprocity (Howes 2011). Research finds that this form of interactive peer play has positive influences on young children's learning and development, such as spatial reasoning (Ramani et al. 2014), self-regulation (Barnett et al. 2008), social and learning competencies (Bulotsky-Shearer et al. 2012), and knowledge of emotion (Torres et al. 2015).

Conflict-based social networks, or conflict networks, refers to peer interactions in which children engage in overt forms of unpleasant aggression, such as fighting or quarreling. It tends to result in physical injuries, maladjustment at school, and risky behaviors in the future, such as alcohol and drug abuse, violent crimes, and depression (Gower et al.

2014; Tremblay et al. 2004). Even though conflicts may not always be aggressive and conflict resolution has been found to be beneficial to children's development (e.g., Killen and Turiel 1991), having conflicts with others may also hinder children's cognitive development. Doctoroff et al. (2006) reported that difficulties with emergent literacy were positively related to the display of aggressive behaviors and negatively associated with prosocial behaviors. Moreover, they found that children who displayed more negative affect are more likely to exhibit emergent literacy difficulties. To date, most of the studies on peer interactions in inclusive classroom contexts either focused on play (e.g., Hestenes and Carroll 2000) or conflict networks (e.g., Luciano and Savage 2007; Mishna 2003; Lancioni et al. 2007). To provide a fuller picture of social networks in ECSE inclusive classrooms, the current study simultaneously examined the patterns of play and conflict networks among children with and without disabilities.

Social networks among young children are complex social phenomena that cannot be sufficiently analyzed by linear and child-centered models. This is because interactions between pairs of children, or social ties, are interdependently embedded within and affected by the broader classroom social networks. The interdependency of peer interactions has been wildly documented in social network theories (e.g., Lusher et al. 2012; Simmel 1950). Children may form social networks based on a social mechanism such as transitivity; that is, having a mutual friend increases the likelihood for two individuals to befriend each other. Without taking into account the interdependency of peer interactions, any finding regarding the effect of individual attributes on the formation of social networks could be misleading (Butts 2008). For instance, given two girls are playmates of each other and they both play with a third girl, without controlling for the transitivity effect, the gender effect on the formation of play networks would be overestimated. Hence, in this study, we applied stochastic tie-based social network analysis to account for the interdependency among children and their social ties.

### Assessing Social Networks in Preschool Classrooms

Preschool children's social networks have been assessed in previous studies using child nomination or child rating scales, direct observations, or teacher report. A child nomination or child rating scale is implemented by asking children to nominate their playmate or to rate the extent to which they like to play with each of their classmates (e.g., Shin et al. 2014; Wu et al. 2001). Direct observations involve repeated observations of each child's naturalistic social interactions with his or her peers at school (e.g., Fantuzzo et al. 1998). Teacher report of children's social networks is usually performed by asking teachers to list each child's closest friends, to identify peer groups (Gest 2006), or to nominate classmates for each child with whom the child appears to like to play the most as well as with whom the child appears to like to play the least (Wu et al. 2001).

For the purpose of this study, we consider teacher report as the more appropriate approach to assess children's social networks in ECSE inclusive classrooms. First, even though child nomination or rating approach provides "insider" perspective on peer interactions, the reliability of young children's self-report might be questionable since their responses can be easily affected by their mood and immediate antecedent events (Shin et al. 2014). Moreover, previous research suggests that young children with disabilities often have a poorer understanding of the types of playmates with whom they like to interact than their typically developing peers (Robertson et al. 2003).

Second, research suggests that teachers are reliable observers of young children's peer interactions since they are able to frequently use ongoing observations and knowledge about each individual child to monitor children's development over time (Cabell et al. 2009; Meisels et al. 1995; Shin et al. 2014). Moreover, teachers may be more able to decipher children's social behavior than researchers who are less familiar with the children, especially with children with disabilities.

Third, moderate to high correlations between teacher report, child report and direct observation have been documented in previous studies (e.g., Fantuzzo et al. 1998; Gest et al. 2003; Neal et al. 2011). For example, Howes et al. (1988) reported high cross-method agreement (i.e., 78–85%) between child nominations, direct observation, and teacher reports of friendships among 3- to 6-year-old children. Similarly, Wu et al. (2001) found that there is a moderate overlap between children's and teachers' perceived peer social networks. They argued that each method presents unique aspects of peer relationships.

### Goals of the Present Study

The goals of this study are two folded. First, we explored child-level and classroom-level social network characteristics in ECSE inclusive classrooms. Second, at the level of peer interactions or social ties, we applied an inferential social network analysis to examine the extent to which disability status affected children's play and conflict networks, and whether play and conflict networks were segregated by children's disability status.

Several hypotheses guided our work. First, based on the evidence that children with disabilities tend to be less socially and linguistically competent (Luciano and Savage 2007), we hypothesized that children with disabilities would experience fewer play interactions and greater conflict interactions in their social networks compared to their

typically developing peers. Second, some evidence from non-inclusive preschool classrooms suggests that children tend to interact with peers sharing similar characteristics, such as language and literacy ability (Delay et al. 2016; Lin et al. 2016), gender (e.g., Fabes et al. 2003), age (e.g., van Hoogdalem et al. 2012), and race (e.g., Fishbein and Imai 1993; Rutland et al. 2005). Particularly, gender homophily has been consistently documented in previous studies (e.g., Farver 1996; Martin and Fabes 2001; Martin et al. 2013; van Hoogdalem et al. 2012) showing that girls tend to interact with girls and boys tend to interact with boys. We hypothesized that disability segregation might occur in ECSE inclusive classrooms even after controlling for children's similarities in language skills, gender, age, and race.

## Method

### Participants

A total of 485 children (281 boys, 204 girls) from 64 ECSE inclusive classrooms were enrolled in this study. The classrooms were located in two states and involved in a larger study generally focused on language and literacy programming in ECSE classrooms. Children were sampled from classrooms who met several criteria, including caregiver consent and English proficiency (i.e., English is child's primary language or child understands and speaks English well). Additionally, children needed to have sufficient verbal (i.e., speak in at least two-word utterances), cognitive, and sensory functioning to participate in the child-level assessments in the study; as such, children with disabilities sampled would be considered to be of moderate to high functioning. In this study, children's age ranged from 34 to 70 months ($M = 51.88$, $SD = 6.24$). Most of the children were Caucasian (78%, $n = 287$). Socio-economic status was captured by maternal highest level of education and annual household income. The majority of mothers had at least some post-secondary education, and the average level of annual household income was $40,001–$60,000 (Table 1).

Disability status was operationalized as whether a child received an Individualized Education Plan (IEP) or 504 plan, which represented 41% of the children in the sample. Children's disability status was dichotomously coded (1 = with disability, 0 = without disability). Parents were invited to identify children's primary diagnosis if it was known. Based on parent report, 40% ($n = 76$) had speech/language impairment, 18% ($n = 35$) had developmental delay, 16% ($n = 30$) had multiple disabilities, 6% ($n = 11$) had autism spectrum disorder, and 5% ($n = 10$) had emotional disturbance, orthopedic impairment, or other health impairment. For the remaining 16% ($n = 30$), no specific diagnose was reported by parents.

The 64 ECSE inclusive classrooms were selected from among 108 ECSE classrooms enrolled in the larger study for the social network analysis. The classroom eligibility criteria for the analysis included: (a) classroom size: there were at least four children represented in the classroom; (b) inclusion: the classrooms contained both children with disabilities and typically developing children; specifically the classroom contained at least two typically developing children and two children with disabilities; and (c) data availability: both play and conflict network data were available for the classrooms.

As presented in Table 1, classrooms included in this study enrolled on average 7.6 children ($SD = 2.08$; range 4–11). The mean percentage of children with disabilities in each classroom was 41% ($SD = 0.16$; range 10–75%). The average percentage of girls in each classroom was 42% ($SD = 0.14$; range 14–71%). Almost all classrooms (98%) had both a lead and assistant teacher, and the 64 lead teachers were primarily female ($n = 40$) and Caucasian ($n = 61$). Their average age was 40.5 ($SD = 9.83$; range 26–63). Twenty percent of them had an associate degree, 15% had a Bachelor's degree, 16% had at least 1 year of courses beyond a Bachelor's degree, and 49% had a Master's degree. The lead teachers majored in at least one of the following areas: early childhood education, elementary education, or special education. Classrooms were most often identified as part of state-funded prekindergarten programs (39%) or Head Start (31%). Classrooms were evenly distributed in regard to geographical location: urban (30%), suburban (38%), and rural (32%).

### Measures

#### *Classroom Play and Conflict Networks*

The primary measures in this study were children's play and conflict networks within the classroom, which were based on a teacher rating scale (see Appendix 1). In the sixth week prior to the end of the academic year, teachers provided two global ratings for every pair of children in the classroom based on their observation over the last 3 months, in terms of how often the pair of children played and had conflict with each other during a typical school day (0 = never, 4 = always). Both play interactions and conflict interactions were assumed symmetrical, meaning that each rating represented the extent to which teachers observed child A and child B played or had conflicts with each other. This undirected rating approach might enhance the reliability of the teacher rating since it does not require teachers, the external observers of peer interactions, to specify exactly which child initiated the interaction. Therefore, in the current study, the play and conflict networks were undirected. Examples of play interactions included engaging in pretend play, giving and sharing toys, exploring objects together,

**Table 1** Descriptive statistics of child and classroom characteristics in ECSE inclusive classrooms

| | Missing | n | % | Mean | SD | Range |
|---|---|---|---|---|---|---|
| **Children characteristics** | | | | | | |
| Gender | 0 | | | | | |
| Boy | | 281 | 58 | | | |
| Girl | | 204 | 42 | | | |
| Age in month | 0 | 485 | | 51.88 | 6.24 | 34–70 |
| Race | 118 | | | | | |
| Caucasian | | 287 | 78 | | | |
| African American | | 42 | 11 | | | |
| Asian | | 5 | 1 | | | |
| Other | | 33 | 9 | | | |
| Language ability (CELF) | 13 | 472 | | 89.84 | 15.53 | 45–131 |
| Disability status | 0 | | | | | |
| Typically developing | | 293 | 60 | | | |
| Have at least one disability | | 192 | 40 | | | |
| Language impairment | | 67 | 44 | | | |
| Developmental delay | | 33 | 22 | | | |
| Multiple disabilities | | 30 | 20 | | | |
| Autism | | 11 | 7 | | | |
| Emotional disturbance | | 3 | 2 | | | |
| Other health impairment | | 2 | 1 | | | |
| Orthopedic impairment | | 2 | 1 | | | |
| Specific learning disability | | 1 | 1 | | | |
| Visual impairment | | 1 | 1 | | | |
| Hearing impairment | | 1 | 1 | | | |
| Diagnose was not available | | 41 | | | | |
| Maternal education | 127 | | | | | |
| Some high school, no diploma | | 23 | 6 | | | |
| High school | | 86 | 24 | | | |
| Some college or a 2-year degree | | 137 | 38 | | | |
| Bachelor's degree | | 58 | 16 | | | |
| Master's degree or higher | | 54 | 15 | | | |
| Annual household income | 140 | | | | | |
| $20,000 or less | | 47 | 14 | | | |
| $20,001–$40,000 | | 109 | 32 | | | |
| $40,001–$60,000 | | 52 | 15 | | | |
| $60,001–$100,000 | | 46 | 13 | | | |
| $100,000–$150,000 | | 63 | 18 | | | |
| More than $150,000 | | 28 | 8 | | | |
| **Classroom characteristics** | 0 | | | | | |
| Classroom size | | 64 | | 7.58 | 2.08 | 4–11 |
| Proportion of children with disabilities | | 64 | | 0.41 | 0.16 | 0.10–0.75 |
| Proportion of girls | | 64 | | 0.42 | 0.14 | 0.14–0.71 |
| Teacher's age | | 64 | | 40.47 | 9.83 | 26–63 |
| Teacher's gender | | | | | | |
| Male | | 20 | 31 | | | |
| Female | | 44 | 69 | | | |
| Teacher's years of experience in preschool classrooms | | 64 | | 4.34 | 0.74 | 2–5 |

collaborating on building blocks. Examples of conflict interactions included quarreling, fighting, kicking, hitting, and shouting. In this study, the teacher-rated peer interactions were used to generate descriptive social network indices and the network objects for exponential random graph models (ERGMs).

*Language Ability*

Children's language ability was assessed by Clinical Evaluation of Language Fundamentals Preschool—Second Edition (CELF, Wiig et al. 2004). CELF was individually administered to preschool children, which contained three subscales measuring both expressive and receptive language skills (i.e., expressive vocabulary, sentence structure, and word structure). CELF has shown high reliability and validity in the previous literature (Reilly et al. 2010; Wiig et al. 2004). In the current study, the Cronbach's alphas for expressive vocabulary, sentence structure, and word structure were 0.71, 0.67, and 0.69, respectively. Standardized composite scores were used in the analysis.

**Data Analysis Approach**

To achieve the first research goal—capturing child-level and classroom-level social network characteristics in ECSE inclusive classrooms, descriptive social network indices (i.e., individual degree centrality and network density) were generated using SNA package in R (Butts 2016). *Individual degree centrality* is a child-level network index that represents the sum of the frequency of interactions associated with an individual child within the classroom, hereafter called "individual play centrality" in the play networks and "individual conflict centrality" in conflict networks. Since classroom sizes varied across classrooms, individual degree centrality was standardized by dividing the raw scores by classroom size (n) minus 1, which is the maximum number of social ties a child could possibly form in the play/conflict network. *Network density* is a classroom-level network index that represents the connectedness of the network as a whole. Network density was calculated by dividing the sum of all the observed ties in the classroom by the number of maximum possible ties [n(n−1)/2]. The standardized individual degree centralities and network density both followed the scale of teacher rating from zero to four.

To approach the second research goal—examining the effect of disability status on children's network formation, inferential social network analysis was applied. Exponential random graph models (ERGMs), also known as p* models, are statistical models examining how and why social networks are formed (e.g., Lusher et al. 2012; Robins et al. 2007). Different from traditional linear models where individuals are treated as the unit of analysis and are assumed to be independent (e.g., Kamps et al. 2015; Kasari et al. 2011), ERGMs are tie-based stochastic models allowing researchers to examine network formation processes while controlling for the interdependency among social ties (Goodreau et al. 2008; Robins et al. 2007; Siciliano 2015).

One limitation of ERGMs is that it can only be used to examine network formation processes based on binary network data in which social ties have binary values (1 = tie is present, 0 = tie is not present). Therefore, in this study we transformed the valued play/conflict networks in which the frequency of play or conflict interactions between each pair of children in the classrooms ranged from zero to four, into binary networks with the cut-off score set at the grand mean of teacher rating (1.94 for play networks and 1.05 for conflict networks). Considering that the small classroom size might lead to less reliable parameter estimates in ERGMs, in the current study, all the individual binary play and conflict networks were pooled respectively to form a larger play network and a conflict network (Schaefer et al. 2010). Between-classroom interactions were restricted by structural zeros (permanent null ties), assuming no cross-class interaction among children in this study. By pooling all the classroom social networks, we were able to investigate fundamental network formation processes across classrooms more reliability. The limitation of this approach was that we were not able to identify unique processes occurred in specific classrooms.

The ERGMs were performed using the statnet package in R (Handcock et al. 2008). Two types of effects were specified in ERGMs: actor covariate effects and network structural effects.

*Actor Covariate Effects*

Actor covariate effects refer to individual characteristics that can potentially influence the network formation process. For undirected networks, two forms of actor covariate effects can be examined using ERGMs (Robins and Daraganova 2013)—main actor effects and homophily effects. The main actor effect explains the extent to which a particular characteristic of the actor increases or decreases his or her probability of forming a play or conflict interaction. A homophily effect measures the extent to which two actors sharing certain characteristics would be more likely to play or have conflicts with each other.

In this study, actor covariates specified in the ERGMs included the main and homophily effects of disability status. The disability main effect examined the extent to which having a disability increased or decreased the probability for the child to play or to have conflicts with peers. The disability homophily effect examined the extent to which children play or have conflicts with peers who shared the same disability status. Other child attributes included in ERGMs as control

variables were gender, age, race, language ability, as well as their corresponding homophily effects.

Classroom size, the proportion of children with disabilities, the proportion of girls in the classroom, teachers' age, gender, and years of experience in preschool classrooms were included to account for heterogeneity across classrooms.

*Network Structural Effects*

Network structural effects refer to the extent to which existing patterns of local network configurations influence subsequent network formation. For example, a triangle structure formed by cliques of three actors is often included in ERGMs to account for interdependence among social ties. The network structural effects examined in this study included *edge, triangle-closing* (also called geometrically weighted edgewise shared partnerships or GWESP, Hunter 2007), and *multiple two-path* (also called geometrically weighted dyadwise shared partnerships or GWDSP, Robins et al. 2009; Siciliano 2015). The visualization of these network structural effects is shown in Table 2. The edge effect is similar to the intercept in linear regression models (Lusher and Robins 2013, p. 42), which predicts the grand-mean tendency for children to form play or conflict interactions in the network after controlling for all the other effects. Triangle-closing and multiple two-path effects altogether represent network transitivity, a social network mechanism through which individuals spread their social ties within the network (e.g., Given Child A plays with Child B and Child B plays with Child C, Child A will choose to play with Child C). This transitivity mechanism is evident if a positive effect of triangle-closing (GWESP) and a negative effect of multiple two-path (GWDSP) are found (Papachristos et al. 2013).

## Results

### Characteristics of Play and Conflict Networks

Our first research goal was to characterize children's play and conflict networks in ECSE inclusive classrooms at both child and classroom levels. At the child-level, as presented in Table 3, individual play centrality ranged from 0 to 3.33 ($M = 1.95$, $SD = 0.61$), and individual conflict centrality ranged from 0 to 3.83 ($M = 1.05$, $SD = 0.71$). Note that children's play and conflict networks were rated using a scale of 0 (Never play/have conflicts) to 4 (Always play/have conflicts). These results suggested that, on average, children in ECSE inclusive classrooms 'sometimes' played with peers and 'rarely' had conflicts with peers. Independent *t*-tests were conducted to compare individual play or conflict centrality between children with and without disabilities. The results showed that children with disabilities had significantly lower individual play centrality than children without disabilities ($t_{(365)} = -5.00$, $p < .01$, Cohen's $d = 0.48$). There was no significant difference in individual conflict centrality between children with and without disabilities. These findings suggested that children with disabilities formed looser play networks but had similar conflict networks compared to their typically developing peers. As shown in Fig. 1, typically developing children were more likely to be situated at the center of classroom play networks, while children with disabilities were more likely to be marginalized and isolated. The social network positions of children with and without disabilities were relatively comparable in classroom conflict networks.

At the classroom-level, network density represents the overall connectedness of a classroom social network. As presented in Table 3, on average, the density of the classrooms play networks was 1.96 ($SD = 0.48$) on a scale of 0 to 4. Unsurprisingly, the play networks' average density was significantly higher than the conflict networks' average density ($M = 1.05$, $SD = 0.55$; $t_{(63)} = 10.00$, $p < .001$).

**Table 2** Network structural effects specified in the ERGM models

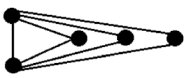
| | |
|---|---|
| Edge |  |
| Triangle-closing (GWESP) |  |
| Multiple two-path (GWDSP) |  |

**Table 3** Descriptive social network statistics at the child- and classroom-level (based on valued network data)

| | N | M | SD | Range |
|---|---|---|---|---|
| **Child level**[a] | | | | |
| All children | | | | |
| Play centrality | 485 | 1.95 | 0.61 | 0.00–3.33 |
| Conflict centrality | 485 | 1.05 | 0.71 | 0.00–3.83 |
| Children with disabilities | | | | |
| Play centrality | 192 | 1.77 | 0.65 | 0.00–3.25 |
| Conflict centrality | 192 | 1.03 | 0.79 | 0.00–3.83 |
| Children without disabilities | | | | |
| Play centrality | 293 | 2.06 | 0.56 | 0.50–3.33 |
| Conflict centrality | 293 | 1.06 | 0.66 | 0.00–3.00 |
| **Classroom level** | | | | |
| Play network density | 64 | 1.96 | 0.48 | 0.60–2.83 |
| Conflict network density | 64 | 1.05 | 0.55 | 0.11–3.05 |

[a]At child level, play and conflict centralities were standardized by dividing the raw score by (classroom size −1)

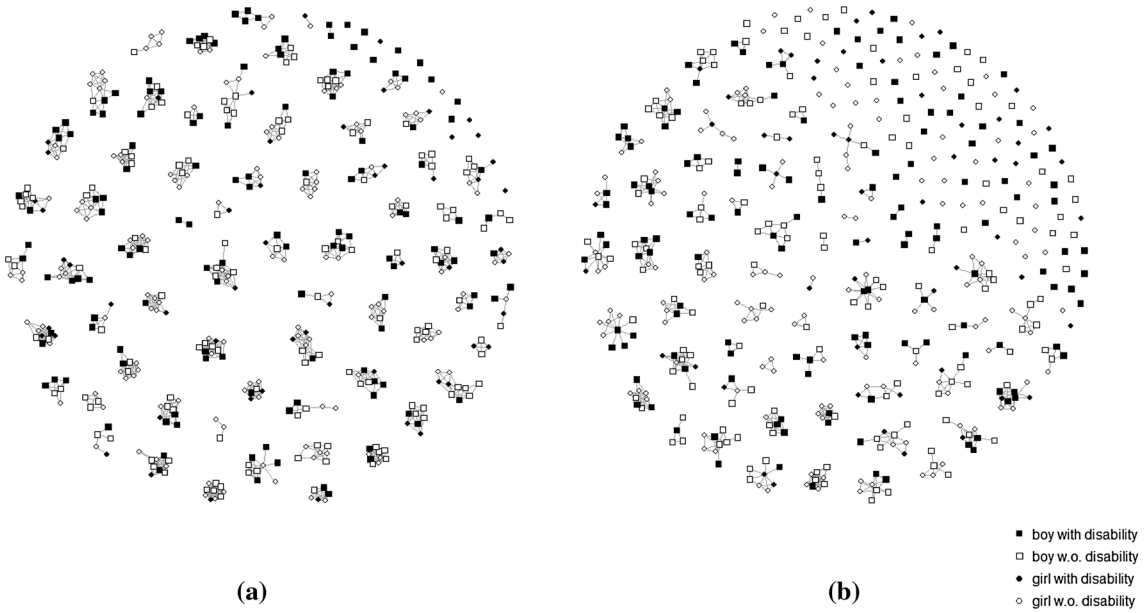



**Fig. 1** Plots of a pooled ECSE classroom play network (**a**) and conflict network (**b**) from 64 classrooms

**Table 4** ERGMs of play and conflict networks in ECSE inclusive classrooms

| | Play model | Conflict model |
|---|---|---|
| **Actor covariate effects** | | |
| Disability status (1 = IEP, 0 = non-IEP) | −0.48 (0.10)*** | 0.00 (0.08) |
| Disability homophily | 0.41 (0.12)*** | 0.22 (0.11)* |
| Age (in month) | 0.01 (0.00)* | 0.01 (0.00)* |
| Age homophily | 0.04 (0.22) | 0.13 (0.20) |
| Gender (1 = girl, 0 = boy) | 0.13 (0.09) | −0.07 (0.07) |
| Gender homophily | 1.15 (0.12)*** | 0.49 (0.10)*** |
| Race (1 = Caucasian, 0 = non-Caucasian) | 0.02 (0.09) | −0.04 (0.08) |
| Race homophily | −0.10 (0.14) | 0.07 (0.13) |
| Language ability (CELF) | 0.01 (0.00)*** | −0.00 (0.00) |
| Language ability homophily | −0.07 (0.33) | −0.01 (0.31) |
| **Classroom covariate effects** | | |
| Classroom size | −0.04 (0.01)** | −0.05 (0.01)*** |
| Proportion of girls | 0.12 (0.15) | −0.04 (0.14) |
| Proportion of children with disabilities | 0.58 (0.16)*** | −0.26 (0.16) |
| Teacher age | −0.01 (0.00)* | 0.01 (0.00)** |
| Teacher gender | −0.04 (0.05) | 0.04 (0.04) |
| Teacher years of experience in preschool classrooms | 0.01 (0.03) | −0.02 (0.03) |
| **Network structural effects** | | |
| Edges | −1.88 (0.75)* | −2.50 (0.63)*** |
| Multiple two-path (GWDSP) | −0.71 (0.05)*** | 0.02 (0.06) |
| Triangle-closing (GWESP) | 0.68 (0.13)*** | 1.19 (0.10)*** |

***p < .001, **p < .01, *p < .05

### The Effect of Disability Status on Play and Conflict Networks

The second research goal was to examine the relations between children's disability status and their play and conflict networks. As presented in Table 4, after controlling for network structural effects, classroom covariates, and children attributes, such as age, race, and language ability, the main effect of disability status significantly predicted children's play networks ($\beta = -0.48$, $SE = 0.10$, $p < .001$) but not conflict networks. The odds that children with disabilities formed play networks with peers was 62% (=exp [−0.48] = 0.62) of the odds of typically developing children.

To examine whether children more often interacted with peers with the same disability status, we found that the homophily effect of disability status was significant in both play and conflict networks ($\beta = 0.41$, $SE = 0.12$, $p < .001$; $\beta = 0.22$, $SE = 0.11$, $p < .05$, respectively), which supports the disability segregation hypothesis. Children were 1.51 times more likely to play with peers who shared the same disability status, and 1.12 times more likely to have conflicts with peers with the same disability status than the other peers.

Results of other actor covariate effects showed that there was a weak age main effect. Older children were more likely to form play and conflict networks than their younger peers ($\beta = 0.01$, $SE = 0.00$, $p < .05$; $\beta = 0.01$, $SE = 0.00$, $p < .05$, respectively). Gender homophily was salient in both play and conflict networks ($\beta = 1.15$, $SE = 0.12$, $p < .001$; $\beta = 0.49$, $SE = 0.10$, $p < .001$, respectively). Compared with mixed-gender dyads, same-gender dyads were more likely to be formed in both play (odds = exp [1.15] = 3.16) and conflict networks (odd = exp [0.49] = 1.63). Moreover, language ability significantly correlated with the probability for children to form play networks ($\beta = 0.01$, $SE = 0.00$, $p < .001$).

In terms of classroom characteristics, classroom size negatively predicted the formation of both play and conflict networks ($\beta = -0.04$, $SE = 0.01$, $p < .001$; $\beta = -0.05$, $SE = 0.10$, $p < .001$, respectively). The proportion of children with disabilities in a classroom positively predicted the formation of play networks ($\beta = 0.58$, $SE = 0.16$, $p < .01$) but not conflict networks. The lead teacher's age was associated with children's play and conflict networks. The higher the lead teacher's age, the more likely the teacher would rate their children's play networks lower ($\beta = -0.01$, $SE = 0.00$, $p < .05$) and their conflict networks higher ($\beta = 0.01$, $SE = 0.00$, $p < .01$).

As has been discussed in the previous section, network structural effects were included in ERGMs to control for the interdependency among social ties formed in the classrooms in order to derive at unbiased estimates of the abovementioned actor covariate effects. The edge effect was negatively significant in both play and conflict networks ($\beta = -1.88$, $SE = 0.75$, $p < .05$; $\beta = -2.50$, $SE = 0.63$, $p < .001$, respectively). The negative edge effect is expected in most of the ERGMs (Snijders et al. 2010), which suggested that children were selective in forming play and conflict networks in this study. The triangle-closing effects on both play and conflict networks were positively significant ($\beta = 0.68$, $SE = 0.13$, $p < .001$; $\beta = 1.19$, $SE = 0.10$, $p < .001$, respectively), and the multiple two-path effect was negatively significant in play networks ($\beta = -0.71$, $SE = 0.05$, $p < .001$) but nonsignificant in conflict networks. The positive effect of triangle-closing and the negative effect of multiple two-path on children's play networks indicated that children's play networks were transitive (Papachristos et al. 2013). The goodness-of-fit statistics are shown in Appendix 2.

## Discussion

The current study examined young children's play and conflict networks in ECSE inclusion classrooms. The findings revealed that children with disabilities were less likely to interact with peers in their play networks compared to typically developing children, but no difference was found between children with and without disabilities in terms of their conflict networks. Furthermore, children were segregated in both play and conflict networks by their disability status, supporting the hypothesis that children with disabilities interact more frequently with peers with than without disabilities. These significant disability main and homophily effects were robust even after controlling for several child, teacher, and classroom factors. The patterns revealed in these play and conflict social networks are not the flip side of one another, warranting the need to take into account both types of social networks to understand how children with and without disabilities interact with each other in ECSE inclusive classrooms.

On the one hand, the finding on the relatively loose play networks for children with disabilities is not surprising. Previous studies have suggested that, compared to typically developing children, children with disabilities have poorer language, cognitive, or social skills to initiate and maintain social relationships, to interpret social cues, or to avoid social comparison with peers (Chamberlain et al. 2007; Eriksson et al. 2007; Mishna 2003; Pierce-Jordan and Lifter 2005). Our findings go further in suggesting that children's disability status has a unique influence on their social networks that is above and beyond the influence of language skills.

On the other hand, our findings suggest that children with disabilities were not different from their typically developing peers in terms of the probability of engaging in conflict networks. Son et al. (2014) noted that peer victimization occurs in children with disabilities due to a confluence of distal (e.g., quality of classroom environment, family income)

and proximal (e.g., social and linguistic competence) factors. However, earlier studies have shown that children with disabilities exhibited fewer inappropriate or self-abusive behaviors than their counterparts in segregated programs (Erwin 1993), and that children with disabilities were more interactive when in an inclusive setting than when they were in self-contained settings (Guralnick et al. 1996). It is likely that ECSE inclusive classrooms provided certain protective environmental factors that buffered against the negative proximal influences on the development of children with disabilities. Future studies should examine the dynamics of inclusive classroom social networks from a more ecological perspective (Neal and Neal 2013).

The nonsignificant difference of conflict networks between children with and without disabilities in ECSE inclusive classrooms seems to be inconsistent with the limited existing literature reporting that children with disabilities were more vulnerable to peer victimization and bullying than their typically developing peers in inclusive classrooms (Luciano and Savage 2007). The incongruent findings might be partly attributed to the fact that previous studies mostly relied on individual interviews or observations of small groups of children, whereas the current study was based on teacher reports of social networks from a large-scale data set including a wide range of ECSE inclusive programs and child populations. Although it is beyond the scope of this study to conclude whether teacher reports precisely reflect the nature of children's social networks, the current study is one of the few studies offering insights on how preschool teachers perceive children's social networks in inclusive classrooms. Considering children and teachers may employ different criteria when assessing peer interactions (Harter and Pike 1984), the findings of this study might be further extended by relating it to teacher attitudes toward inclusion and other teacher characteristics (Lee et al. 2015).

Another major finding of this study was the disability homophily effect in ECSE inclusive classrooms. The ECSE classroom social networks were segregated by children's disability status—typically developing children more often played or had conflicts with typically developing children than with children with disabilities; children with disabilities more often played or had conflicts with children with disabilities. Our finding extends previous research (e.g., Buysse et al. 1997) by suggesting that disability homophily may occur in multiple forms of peer interactions and not just in play. The disability homophily effect might be attributed to the social gaps between children with and without disabilities in terms of social skills, self-expectation and competence (e.g., Chamberlain et al. 2007; Eriksson et al. 2007). It could also be that interacting with children of the same disability status may have reinforced and validated children's attitudes and beliefs about themselves (Kubitschek and Hallinan 1998).

Other than the main and homophily effects of disability status, the ECSE inclusive preschool classrooms showed many common network features that previous studies have reported based on Head Start or noninclusive preschool classrooms. Overall, our descriptive findings showed that children with and without disabilities were more likely to form play networks than conflict networks in classrooms. Additionally, older children were found to interact with peers more often than younger children. This might be because older children possessed more advanced skills critical to their physical, cognitive, and social development (Parten 1932). The age homophily effect was not significant in children's play or conflict networks. This might be because the majority of children in the sample were 4-year-old children; there might not be enough variance of age in these classrooms to test the age homophily effects. Thus, the nonsignificant age homophily effect should be interpreted with caution. The gender homophily effect was salient in both play and conflict networks in ECSE inclusive classrooms, suggesting that gender segregation is a universal social phenomenon across different preschool classrooms contexts. Furthermore, language ability was positively associated with children's play networks, which is in line with existing research that language ability is required for children to develop and retain positive social relationships (Stanton-Chapman et al. 2008).

Several classroom characteristics were found to affect children's social networks. The negative effects of classroom size on the formation of both play and conflict networks are in line with social network research indicating that the tendency for children to form an additional social network tie decreases as the network size increases (Snijders et al. 2010). Interestingly, the proportion of children with disabilities in the classroom was found to positively relate to children's play networks. This might be because as classrooms become more diverse, children become more understanding and accepting of children with disabilities (Odom and Bailey 2001). Note, however, that the majority of the classrooms in our sample had less than 41% of children with disabilities. Therefore, the result might not be generalizable to classrooms in which a large proportion of children have disabilities. The lead teacher's age was associated with children's play and conflict networks. This effect remained significant even after teachers' years of teaching experience was taken into account. Future research is needed to further explain why older teachers tend to perceive children's play networks more negatively and conflict networks more positively compared to younger teachers.

There are several limitations in this study. First, when considering children with disabilities, only children who were moderate to high functioning participated in this study. The results may be different if we include children who had more significant disabilities. Additionally, the study did not

have enough statistical power and information necessary to examine the social networks of children with specific types of disability. However, many of our findings are in line with the literature that focused on specific types of disability. For example, Chamberlain et al. (2007) found that compared with typically developing peers, children with Autism Spectrum Disorder (ASD) were less accepted by their peers. Gender homophily has also been documented among children with ASD (Kasari et al. 2011).

Second, peer social networks were captured by teacher rating only, which may introduce teachers' bias in the measurement. However, research suggests that teachers are reliable observers of young children's interactions since they are able to frequently use ongoing observations to monitor children's development over time (Cabell et al. 2009; Meisels et al. 1995). Moreover, the teacher rating scale has shown construct validity in previous studies (Lin et al. 2016, 2017) reporting that teacher-report frequency of peer interactions was positively associated with learning-related behavior, social skills, language and literacy skills, and negatively associated with problem behaviors. Additionally, doing an intensive direct observation was not feasible due to the large number of classrooms participated in this study. Self-report measures based on students' self-report also might not be suitable for this study because most of the existing measures were designed for typically developing children and not for children with disabilities.

Third, children's social networks were based on one-time measurement assessed the end of the academic year. Although teachers were asked to evaluate children's play and conflict social networks based on their observations over a prolonged period of time (i.e., 3 months), preschool children's social networks are dynamic and changing from time to time. Understanding the pattern of change might provide new insights into how children with and without disabilities develop in the context of inclusive classrooms.

Fourth, while the current study depicts the characteristics of social networks in ECSE inclusive classrooms, the underlying motivation and social mechanisms of children's play and conflict networks were not assessed or interpreted from a first-person perspective. This limits our interpretations on why certain structures of social networks were formed and how these networks were perceived by children. Future studies are needed to tap into these underlying psychological processes.

Fifth, the current study investigated fundamental network formation processes underlying ECSE preschool classrooms based on pooled classroom play or conflict networks. While this approach allowed us to identify universal social network mechanisms across classrooms, it limited our ability to identify unique processes occurred in specific classrooms. As multilevel social network analysis becomes more user friendly and practical (Lazega and Snijders 2015), future research is necessary to account for classroom-level variance in order to gain a fuller understanding of how classroom social networks are formed.

Despite the limitations, the current study is one of the few studies examining the nature of classroom social networks in the context of ECSE inclusive classrooms. As Vygotsky (1978) stated, "It is through others that we become ourselves" (p. 987), understanding the nature of social networks in ECSE inclusive classrooms is a necessary step toward advancing our understanding of social influences on children's learning and development in inclusive education (Downing and Peckham-Hardin 2007). Our findings provide insights into how to create a more interactive classroom environment to promote social learning and development for both children with and without disabilities, and will guide future research to generate effective instructional approaches to foster positive social networks for children in ECSE inclusive classrooms.

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**Author Contributions** All authors contributed extensively to the work presented in this paper. JC conceptualized and implemented the study, conducted literature review, data analysis, and took the lead on drafting and revising the manuscript; T-JL participated in the conceptualization of the study, provided guidance for data analysis and interpretation, facilitated in drafting and the critical revisions of the manuscript; LJ and BS made substantial contributions to the study design and data collection, and assisted with writing, reviewing, and revising the manuscript.

**Compliance with Ethical Standards**

**Conflict of interest** The 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 was obtained from all individual participants included in the study. This article does not contain any studies with animals performed by any of the authors.

## Appendix 1: Teacher Rating Scale of Children's Play and Conflict Networks

During a typical school day, children in your class enjoy **playing** with some children more than others. Examples of play behavior are pretend play, giving and sharing toys, exploring objects together, and collaborating on building

blocks. We are interested in learning about how frequently the following children in your classroom play with one another.

Please write the number (0, 1, 2, 3, or 4) that best describes how often the child in column 1 (shaded) plays with each child across the top row ***during a typical school day***, based on your observations over the last 3 months. Do this for all child-pairs listed.

0 = Never play
1 = Rarely play
2 = Sometimes play
3 = Often play
4 = Always play

Example: The teacher recorded that Child B "sometimes plays" with Child A by placing a 2 in the second column and second row.

| Child name | Child A | Child B | ____ | ____ | ____ | ____ | ____ | ____ | ____ |
|---|---|---|---|---|---|---|---|---|---|
| Child A | X | -- | -- | -- | -- | -- | -- | -- | -- |
| Child B | 2 | X | -- | -- | -- | -- | -- | -- | -- |
| ____ | -- | -- | X | -- | -- | -- | -- | -- | -- |
| ____ | -- | -- | | X | -- | -- | -- | -- | -- |
| ____ | -- | -- | | | X | -- | -- | -- | -- |
| ____ | -- | -- | | | | X | -- | -- | -- |
| ____ | -- | -- | | | | | X | -- | -- |
| ____ | -- | -- | | | | | | X | -- |
| ____ | -- | -- | | | | | | | X |

During a typical school day, children in your class may have **conflict** with some children more than others. Examples of conflict behavior are quarreling, fighting, kicking, hitting, and shouting with each other. We are interested in learning about how frequently the following children in your classroom have conflict with one another.

Please write the number (0, 1, 2, 3, or 4) that best describes how often each child in column 1 (shaded) has conflict with each child across the top row ***during a typical school day*** based on your observations over the last 3 months. Do this for all child-pairs listed.

0 = Never has conflict
1 = Rarely has conflict
2 = Sometimes has conflict
3 = Often has conflict
4 = Always has conflict

Example: A teacher recorded that Child B "never has conflict" with Child A by placing a 0 in the second column and second row.

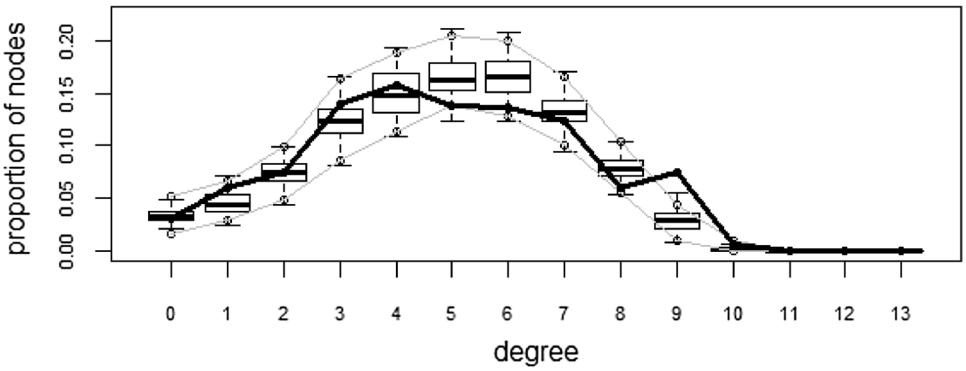
| Child name | Child A | Child B | ____ | ____ | ____ | ____ | ____ | ____ | ____ |
|---|---|---|---|---|---|---|---|---|---|
| Child A | X | -- | -- | -- | -- | -- | -- | -- | -- |
| Child B | 0 | X | -- | -- | -- | -- | -- | -- | -- |
| ____ | -- | -- | X | -- | -- | -- | -- | -- | -- |
| ____ | -- | -- | | X | -- | -- | -- | -- | -- |
| ____ | -- | -- | | | X | -- | -- | -- | -- |
| ____ | -- | -- | | | | X | -- | -- | -- |
| ____ | -- | -- | | | | | X | -- | -- |
| ____ | -- | -- | | | | | | X | -- |
| ____ | -- | -- | | | | | | | X |

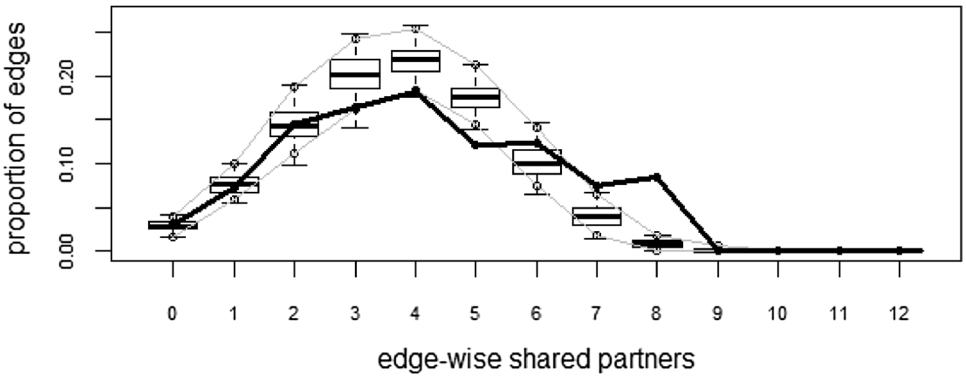
## Appendix 2: Goodness-of-Fit Tests for ERGMs

Several goodness-of-fit measures were applied to assess the extent to which the ERGMs (Table 4) were able to reproduce certain network properties that were not specifically assessed in our models (i.e., "out-of-model" statistics, Hunter et al. 2008). The most common out-of-model statistics used to assess goodness of fit are the distribution of individual degree centrality and the distribution of edge-wise shared partners (Siciliano 2015). These goodness-of-fit plots were generated using the gof function in the statnet program in R (Handcock et al. 2008).

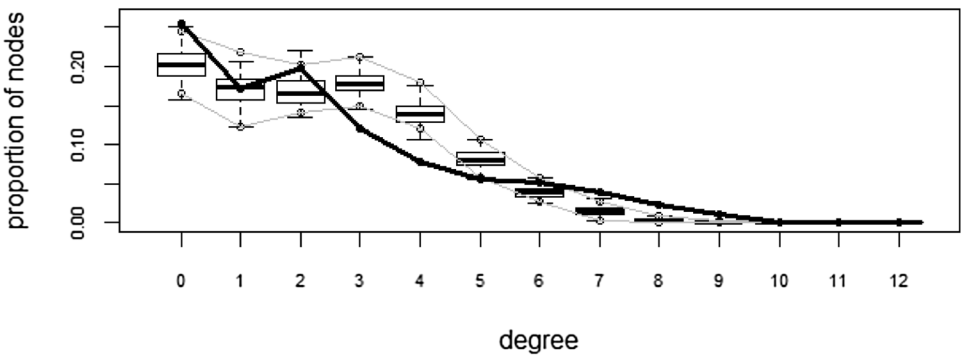
For each of the plots presented in this appendix, the thick black line refers to the observed value of a given statistic. The boxplots refer to the distribution of this statistic generated by simulated networks based on the parameters of the ERGM model specified in this study. The plots showed that both play and conflict network models reasonably captured the general trend of the observed interactions, even though the play network model underestimated the number of children whose individual degree centrality was nine and those who had eight edge-wise shared partners. The conflict network model generally fit well except that it overestimated the number of children whose individual degree centrality was three or four and who had one or two edge-wise shared partners. The model also underestimated the number of children who had five or six edge-wise shared partners. These might be caused by the skewed distribution of individual degree in conflict networks because only a few children were involved in conflict interactions.

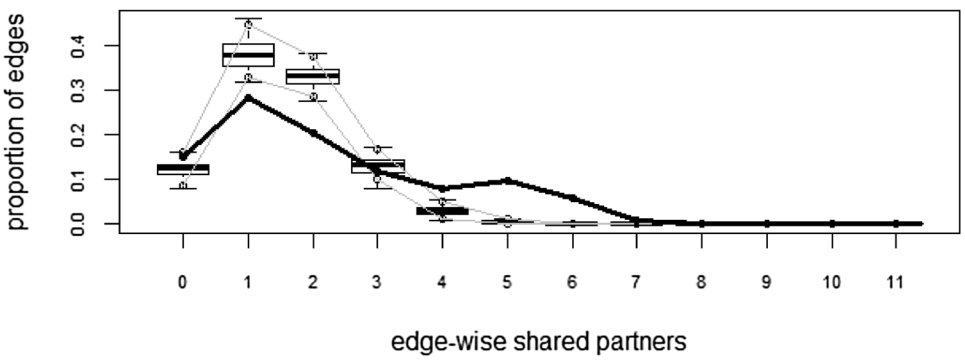
Assessment of goodness of fit for the model of play networks




Assessment of goodness of fit for the model of conflict networks



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