The Breadth of Peer Relationships among Externalizing Preschoolers: An Illustration of the Q-Connectivity Method

Laura D. Hanish, Carol Lynn Martin, Richard A. Fabes, and Helene Barcelo

Arizona State University
Abstract

We studied the relations between externalizing-related behaviors and social breadth (the number of peers children interact with and the extent to which they maintain interactions over time) in preschoolers. Using the Q-connectivity method to assess social breadth, which is a variation on social network analysis, we explored how externalizing-related behaviors varied in relation to: 1) the continuity of social breadth and 2) patterns of decline in social breadth across time. Findings suggested that externalizing preschoolers were less likely than their non-externalizing peers to maintain continuity in peer interactions across time. The findings contribute to an understanding of externalizing preschoolers’ social breadth and time spent with peers. The utility of the Q-connectivity method for future research is also discussed.
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One challenge faced by contemporary researchers interested in social interactions is understanding how exposure to externalizing peers contributes to the spread of aggression and related problem behaviors. This issue has important implications for prevention scientists, who have found the effectiveness of intervention programs hindered by peer contagion processes (Dishion, Spracklen, Andrews, & Patterson, 1996; Poulin, Dishion, & Burraaston, 2001), as well as for educators, who recognize that classroom social norms supporting aggressive behavior can undermine the learning environment (Henry et al., 2000). Central to understanding how peer contagion processes operate is an awareness of the potential extent of influence that externalizing children have on their peers. Thus, it is necessary to understand how far-reaching externalizing children’s connections are with their peers – how many peers externalizing children interact with and the extent to which they maintain interactions with peers over time. In the present study, we explored the breadth of young externalizing children’s relationships with peers. To do so, we used the $Q$-connectivity method (Barcelo & Laubenbacher, 2005), a variation on social network methods that capitalizes on multiple samples of social networks over time, which can be used to calculate social breadth. Specifically, in this study, we collected numerous observations of children’s peer interactions over time, providing an extensive picture of the dynamics of peer interactions. An additional unique feature of this study is that we drew on a sample of preschoolers; this age group has been relatively neglected in past research in this area (see Hanish, Martin, Fabes, Leonard, & Herzog, 2005; Snyder, Horsch, & Childs, 1997 for exceptions), although the peer relationships of young children lay the foundation for their later peer experiences.
One of the most interesting, but least well studied, aspects of children’s peer relationships is the substantial variation in the breadth of children’s peer affiliations. Children are most likely to engage peers who are similar to themselves on demographic dimensions, such as sex, and behavioral dimensions, such as aggressiveness (Cairns, Cairns, Neckerman, & Gest, 1988; Espelage, Holt, & Henkel, 2003); yet, with numerous peers in a class to choose as affiliation partners, there is marked individual variation in the number and types of peers with whom children interact. Thus, it is not surprising that some peers never interact with one another whereas others interact frequently (Snyder, West, Stockemer, & Gibbons, 1996). To complicate matters, relationship patterns change over time: friendships form, persist for short or long periods of time, and often dissolve; peers move into or out of social networks; and children’s social positions can become more or less prominent over time. Consequently, there is both stability and fluidity in children’s peer affiliations over shorter (e.g., moment-to-moment, week-to-week), and longer (e.g., month-to-month, year-to-year) periods of time (Cairns, Leung, Buchanan, & Cairns, 1995; Estell, Cairns, Farmer, & Cairns, 2002; Martin, Fabes, Hanish, & Hollenstein, 2005). These features of children’s peer relationships contribute to substantial individual variability in the breadth of children’s peer affiliations and the persistence of these affiliations across time, and likely contribute to important developmental outcomes.

It is this variability in young children’s social breadth that we highlight in the present study. Social breadth refers to the range of peer affiliates – that is, the number of peers that each child interacts with – and the extent to which these peer affiliations are observed over time. As such, social breadth represents a construct that is distinct from conceptions of friendship, social status, or membership in social networks because it reflects the comprehensiveness of children’s peer affiliations (and the maintenance of these affiliations over time) rather than affective mutuality, behavioral homophily, or the quality of their relationships per se, although it may
relate to these factors. The roots of this construct can be seen in the work of Waldrop and Halverson (1975), who studied the extensiveness of peer relationships.

From a developmental perspective, social breadth reflects a particularly central feature of children’s peer relationships during the preschool period. It is during these years that children move away from a general tendency to play alone or alongside other children and begin to engage in increasing levels of social interactive play (Rubin, Bukowski, & Parker, 1998). This is reflected in the fact that preschoolers’ social networks become larger, more dense, and more organized with age (Strayer & Santos, 1996; Vespo, Kerns, & O’Connor, 1996). Thus, we would expect great variability in social breadth among young children, as some children begin to develop large, comprehensive, and stable peer networks, and others, who may be more immature or less socially skilled, are less likely to engage with peers.

There is reason to believe that social breadth varies in relation to young children’s externalizing behaviors. Prior studies have indicated that structural aspects of preschool children’s peer relationships are related to their exhibition of externalizing behaviors, such that the peer relationships of aggressive children tend to be more sparse and less stable over time. For instance, van den Oord, Rispens, Goudena, and Vermande (2000), who collected sociometric nomination data with over 1000 preschool children, found that children who were less likely to be members of cliques and children whose peer relationships were less transitive (i.e., children who were disliked by their friends’ friends) were rated by teachers as displaying more problem behaviors (e.g., aggression, attention problems, and fear). Similarly, Snyder et al. (1997) found that aggressive preschoolers, compared to nonaggressive preschoolers, developed fewer relationships with peers that were stable over time. Additionally, studies have demonstrated that aggressive children have lower social preference scores and are more likely to be rejected by peers than their nonaggressive counterparts (Olson, 1992; Snyder et al., 1997). Thus, we expect
social breadth to be negatively related to externalizing behaviors and positively related to regulatory abilities (a correlate of externalizing behavior) among young children.

**The Use of the Q-Connectivity Method to Measure Social Breadth**

Social network methods have demonstrated utility for identifying the structural dimensions of children’s peer relationships (e.g., membership in or isolation from social networks, network centrality, the social distance connecting a child to his or her peers, etc.). Most often, social network data have been obtained using sociometric nominations collected at one discrete time; thus, the resulting social networks represent aggregated views of relationships that provide relatively static pictures of children’s affiliation patterns at that particular point in time (e.g., Cairns et al., 1988). Recently, however, we have seen the development of new social network methodologies that facilitate the use of data collected at multiple points in time (e.g., Moody, McFarland, & Bender-deMoll, 2005; Huisman & Snijders, 2003). This line of work, though still in its infancy, has the potential to enhance our understanding of social developmental processes above and beyond what can be learned from maps of social networks obtained at a single time. In the present study, we relied on observations of children’s peer interactional partners obtained over the course of a semester. These longitudinal observations lend themselves to an assessment of time-dependent social processes, and we used the Q-connectivity method as a basis for calculating children’s social breadth over time. Compared to traditional social network analysis methods, the Q-connectivity method allows for a more extensive view of the dynamics of interaction patterns rather than simply structural features of these patterns.

The Q-connectivity method involves translating mathematical theory into techniques that can be used to measure children’s social patterns with classmates (or other specified group members) over time (Barcelo & Laubenbacher, 2005). It is based on the Q-connectivity theory for simplicial complexes, which is a method of representing dynamic (i.e., time-dependent)
processes as a series of graphs containing vertices (nodes) indicating agents (e.g., children) and edges linking related vertices to indicate connections among agents. It has been applied in diverse contexts such as epidemiological contact networks and search-and-rescue operations (Barcelo & Laubenbacher, 2005, 2006). Multiple graphs are produced that depict changes in patterns of vertices and edges over “contact” time; specifically, each graph depicts the number of observed contacts with other individuals. Moreover, successive graphs can be embedded within earlier graphs, and as the graphs increase, they indicate a greater number of observed contacts with the same individual(s). One noteworthy feature of the Q-connectivity method is that networks are mapped individually for each child in the sample (rather than for a group of children – classmates or schoolmates – as is often done with social network procedures, e.g., Cairns et al., 1988; Richards & Rice, 1981). Thus, each child’s unique patterns of interaction are readily visible (using graph visualization techniques) and quantifiable. This is a useful distinction to make because, when networks are mapped for a group (e.g., classroom, grade) as a whole, information about isolates’ networks as well as information about peers who are more peripheral to individual children’s social circles is sacrificed in exchange for a parsimonious representation of the social structure of the group as a whole.

As applied to the study of peer relationships, Q graphs are created for each target child in a class (or other social group), where Q = the number of days (or other specified period of time) in which a target child interacted with one or more of the same peers. Thus, this method produces multiple graphs across time for individual children. Children who interact more frequently over time with one or more peers have more graphs than children who interact with the same peers on fewer days. Each vertex on each graph reflects a peer with whom the target child interacted on at least Q days (circled vertices indicate female peers and square vertices indicated male peers; see Figures 1 and 2 for examples). Thus, a child who interacts with Peer X...
on 2 days would have a vertex for Peer X in $Q = 1$ and $Q = 2$ graphs. A child who interacts with Peer X on 4 days would have a vertex for Peer X in $Q = 1$, $Q = 2$, $Q = 3$, and $Q = 4$ graphs, and so on. In this way, the method captures the frequency of contact or exposure a target child has with each peer in his or her class over time. The sum of the number of vertices reflects the number of children that the child had contact with over a given period of time (breadth). The entire pattern of graphs, that is, the changes in the number of vertices over different levels of $Q$, provides a quantifiable view of the continuity of contact with others, or a “continuity of breadth.”

To be clear, time is represented at the macro-level – reflecting a time-ordered sequencing of interactions but not moment-to-moment interactions. That is, time is reflected in the number of days a particular child was observed playing with other children. As such, the time dimension in Q-methodology is such that children who are observed playing together for 2 days over the course of the semester could have been observed playing together on 2 consecutive days or the 2 days could have been separated by several days, weeks, or even months. Thus, time reflects the continuity of patterns of young children’s interactions across the semester.

One important feature of the Q-connectivity method is that peer interaction patterns can be easily visualized. Compare the pattern of peer interaction with regard to social breadth for Boy 709 and Boy 739 (both are in the same class), as shown in Figures 1 and 2, respectively. At all levels of $Q$, Boy 739 had more vertices than Boy 709. Boy 739 also had more edges connecting peers than did Boy 709. Moreover, Boy 739 maintained interactions with multiple peers over longer periods of time. Indeed, he interacted with Boys 737 and 1023 over 18 days, and the relationship with Boy 1023 persisted even longer. In comparison, Boy 709 maintained repeated interactions with Boy 739 for just 11 days. Children who interact with many peers have higher vertex scores (i.e., greater breadth) than children who interact with relatively few peers (i.e., lower breadth). Thus, Boy 739 had greater social breadth, over both shorter and longer
periods of time (i.e., Q), than did Boy 709. These graphs provide the basis for calculating vertex scores, which represent social breadth at each level of Q.

Purpose of the Study

The primary goal of this study was to evaluate preschoolers’ social breadth and examine the relations of this to externalizing behaviors. To do so, we used the Q-connectivity method to calculate social breadth at lower levels of Q (which reflect peer relationships that do not persist over time) as well as greater levels of Q (which reflect longer lasting peer relationships). We tested the relations with multiple aspects of externalizing behavior – namely, aggression, attention problems, anger, and effortful control (which is inversely related to externalizing behavior and a risk factor for externalizing behavior) – because this allowed us to test the robustness of the patterns.

We explored how the relations between externalizing behavior and social breadth varied according to the depth or persistence of children’s peer relationships across time. We addressed this issue in two different ways. First, we examined the relations between externalizing behavior and social breadth at each of several consecutive levels of Q (recall that level of Q reflects the number of days a child was observed interacting with a particular peer). We expected that the relations would be weak at low levels of Q because these reflect relatively short-lived peer relationships (i.e., peers are only required to interact over a small number of days to be counted), and significant (negative for aggression, attention problems, and anger and positive for effortful control) at medium to high levels of Q because these reflect more enduring peer relationships. Our hypotheses are supported by previous studies that have shown relations between externalizing behavior and other aspects of children’s peer relationships (Snyder et al., 1997; van den Oord et al., 2000).
Second, although social breadth as measured via Q methodology will decline over time for all children (as children would be expected to have more short-term peer relationships and fewer long-term, lasting peer relationships and because each Q graph is embedded in the previous graphs), we expect there to be meaningful variations in the rate of decline in social breadth scores over time. Thus, children who have relatively more difficulty maintaining peer relationships should show relatively rapid drop-offs in social breadth whereas those who are relatively more sociable and skilled at maintaining peer relationships should exhibit a slower decline in breadth. We compared externalizing behavior to variations in patterns of change in social breadth. We expected that externalizing behaviors would be related to a relatively steep decline in social breadth. Our hypothesis was based on prior studies that have demonstrated that the quality and duration of externalizing children’s peer relationships tend to be lower than those of more competent children (Snyder et al., 1997).

Methods

Participants

Participants were students and teachers from six classrooms in three preschools in an urban area in the southwest. All of the schools provided full-day childcare. Class sizes ranged from 17 to 20. All members of each class were recruited for participation in the study; the parental permission rate was 98%. The sample consisted of 97 children, ranging in age from 37 to 64 months ($M = 48.7$, $SD = 6.1$). There were similar numbers of boys (52%) and girls. Children were predominantly non-Hispanic White (55%) and Hispanic White (32%; predominantly Mexican American), with the remainder Native American (7%) and African American (6%). Family income ranged from under $10,000 to over $140,000 (median $50,000-$60,000). Almost two-thirds of the children lived in two-parent families (64%).

Procedures and Measures
For the present study, parents reported on child and family demographic variables and teachers reported on children’s externalizing behaviors in the classroom. Additionally, behavioral observations of children’s peer interactions in the classroom were used as the basis for calculating vertex scores.

**Observations of peer interactions and calculation of vertex scores.** During the fall semester, trained independent observers used a scan observation procedure to record children’s peer interaction partners (Hanish et al., 2005; Martin & Fabes, 2001). Observers were in children’s classrooms daily during the hours in which most children were awake and in attendance (e.g., between 9:00 am and 4:00 pm, excluding nap time), and they observed children during structured (e.g., teacher-led story-time) as well as unstructured (e.g., free play) activities in the classroom and on the playground. Observers rotated through a randomly ordered list of children, observing each child for 10 seconds. Once observers reached the bottom of the list, they waited for approximately 5 minutes and then began again. Mid-way through the semester, the list was re-ordered to control for any possible bias due to order of being observed.

Observations were conducted using handheld computers. A total of 28,726 usable observations were collected. An average of 252 observations per child were obtained (range was 53 to 484). There were no univariate outliers for the number of observations. Observers recorded whether each child was present and available for coding, present but unavailable (e.g., in the bathroom, in the director’s office), or absent. Several codes were recorded for each child, but for the purposes of the present study, only the peer partner codes are relevant. Whenever target children were observed with peers (including both social and parallel play activities), observers recorded as many as five peer partners. A total of 24.7% of the peer interactions included a single partner, 9.2% included two partners, 3.4% included three partners, 1.2% included 4
partners, and only 0.8% included five partners; the rest (60.9%) had no peer play partners (i.e., solitary activities or interactions with the teacher).

Prior to beginning data collection, observers were extensively trained on the coding procedures. Reliability was assessed on a regular basis throughout the semester by having two independent observers simultaneously code the same child (obtained on 12.9% of all observations). Reliability estimates for the peer partner estimates were high; percent agreement was 91% for number of peer partners and 96% for identity of peer partners. These observational procedures have been used in previous studies and have demonstrated very good reliability and validity (Fabes, Shepard, Guthrie, & Martin, 1997; Hanish et al., 2005; Martin & Fabes, 2001).

Social breadth was defined as the number of peers observed to interact with a target child at each value of Q (where Q indicates the number of days the target child interacted with one or more peers). To simplify interpretation of vertex scores (because multiple observations were conducted each day), to be counted as a peer – and thus be considered a vertex – for a particular day, the target child had to be observed interacting with him/her at least once during the day. For each value of Q, the number of vertices for each target child was summed. Thus, the number of vertices at Q = 1 indicates the number of peers that a target child interacted with on at least one day during the semester; the number of vertices at Q = 2 indicates the number of peers that a target child interacted with on at least two days, and so on. The number of vertices was calculated at each level of Q for each child.

*Teachers’ ratings of externalizing behaviors in the classroom.* Teachers completed several measures of externalizing behavior: aggression, attention problems, anger, and effortful control (which reflects children’s regulatory abilities and is negatively related to externalizing behavior). Aggression and attention problems were measured using the Aggressive Behavior (25 items, sample item “this child attacks people”) and Attention Problems (9 items, sample item
“this child can’t concentrate”) subscales of the Teacher Report Form of the Child Behavior Checklist (CBCL-TRF; Achenbach & Rescorla, 2000). Each item was completed using a 3-point Likert-type scale. Both scales have been shown to be reliable and valid for preschool children (Achenbach & Rescorla, 2000).

Anger and effortful control were assessed using brief subscales of the Child Behavior Questionnaire (CBQ; Goldsmith & Rothbart, 1991; Rothbart, Ahadi, & Hershey, 1994). This measure has been used extensively with young children in prior research to assess negative emotions and regulatory abilities. The items on the CBQ were completed using a 7-point Likert-type scale, with response options ranging from extremely untrue of this child to extremely true of this child. The Anger subscale consisted of 10 items (sample item was “gets mad when provoked by other children”, alpha = .92). Effortful control was created from a composite of three subscales tapping Attention Shifting (4 items, sample item was “can easily quit working on a project if asked”, alpha = .82), Attention Focusing (9 items, sample item was “when drawing or coloring in a book shows strong concentration”, alpha = .78), and Inhibitory Control (10 items, sample item was “can lower his/her voice when asked to do so”, alpha = .94). The Attention Shifting, Attention Focusing, and Behavioral Inhibition subscales were highly correlated, average $r(88) = .68$, $p < .001$, and were averaged together to create an effortful control composite score as recommended by Rothbart et al. (1994).

Results

After examining the distributions of social breadth and externalizing measures, we tested two research questions. The first questioned whether externalizing behaviors are related to social breadth at each of several consecutive levels of Q (with lower levels of Q representing more short-lived interaction patterns and with higher levels of Q representing more persistent
The second research question concerned whether externalizing behaviors are related to variations in the pattern of change in social breadth across levels of Q.

**Distributions of Vertex Scores**

Descriptive statistics for vertex scores at Q = 1 through Q = 15 are presented in Table 1. Because the largest class size for this sample was 20 (range 17 to 20), vertex scores could not exceed 19 (i.e., at most, only 19 classmates were available as peer interactants). At Q = 1, vertex scores ranged from a low of 4 to a high of 19, and the mean of 16.1 indicated that, on average, children interacted with almost every classmate at least once in the semester. As expected (and as a result of the embeddedness of the graphs), mean vertex scores decreased steadily over time, and at Q = 15, the mean of 1.5 indicates that, on average, children were observed to interact with only one or two peers on at least 15 days over the course of the fall semester. Note, however, that the maximum score of 8 suggests that some children maintained interactions with as many as 8 classmates for at least 15 days.³ Vertex scores were normally distributed; no vertex score exceeded recommended cutoff scores of skewness = 2 or kurtosis = 7 (Curran, West, & Finch, 1996).

**Demographic Correlates of Vertex Scores**

Vertex scores were modestly sensitive to age-related differences among preschoolers. At Q = 1, age was marginally correlated with vertices, \( r(97) = .17, p = .10 \). However at Q = 2 through 15, the correlations between age and number of vertices were of modest magnitude and significant at \( p < .05 \) or better, average \( r(97) = .27 \). There were no sex or ethnic differences in vertex scores at any level of Q. Children who are more frequently absent from school have fewer opportunities to be observed interacting with peers; vertex scores were significantly correlated with the proportion of time that children were absent from school or unavailable (e.g., in the bathroom or napping), such that children who were absent more frequently had lower vertex
scores at Q = 1 through Q = 15, average $r(97) = -.43$, all $ps < .001$. Vertex scores also varied by classroom, perhaps due to differing number of available classmates or variations in classroom characteristics, multivariate $F(75, 405) = 2.03, p < .001$. Thus, child age, absences/unavailability, and classroom (treated as a random effect) were entered as covariates in subsequent analyses.⁴

**Description of Externalizing Variables**

Table 2 provides descriptive statistics for the externalizing-related variables: aggression, attention problems, anger and effortful control. None of the externalizing-related variables were significantly skewed according to the criteria described by Curran et al. (1996). There were no age or racial differences in any externalizing variable. However, sex was marginally related to aggression, $t(86) = 1.67, p = .10$ and significantly related to attention problems, anger and effortful control, $ts(86, 87, 87) = 3.01, 3.18, \text{and} -3.34, ps < .01, .01, \text{and} .001$. Boys scored higher on aggression, attention problems, and anger and lower on effortful control than girls ($M$s = 7.9, 3.6, 4.3, and 4.2, $SD$s = 9.5, 4.1, 1.3, and 1.1 respectively for boys; $M$s = 4.6, 1.3, 3.4, and 5.0, $SD$s = 9.3, 2.8, 1.4, and 1.1, respectively for girls). Thus, sex was also controlled in subsequent analyses.

**Relations between Externalizing Behaviors and Social Breadth**

Using SAS (9.1) Proc Mixed, we conducted mixed model regressions to assess the relations between externalizing-related behaviors (aggression, attention problems, anger, and effortful control) and breadth at Q = 1 through 15. For each analysis, age, sex, and school absences/unavailability were entered as fixed covariates and classroom was entered as a random covariate. Separate analyses were conducted for aggression, attention problems, anger, and effortful control due to high intercorrelations among the externalizing variables (average $r = .73$). Further, vertices at each value of Q were analyzed separately to test for variations in the relations between externalizing behavior and social breadth across time.⁵
Table 3 presents the regression estimates, standard errors, t-values and significance levels for the effects on vertices attributable to aggressive behavior, attention problems, anger, and effortful control. The results indicated that externalizing behavior was unrelated to vertices at low levels of Q. However, at medium to high levels of Q, aggression, attention problems, and anger were negatively related to vertices and effortful control was positively related to vertices. Specifically, for aggression, statistically significant effects were found at Q values of 9 and above (with a marginally significant effect at $p = .06$ at $Q = 11$). Significant effects were obtained for attention problems at Q values greater than 5 (with a marginally significant effect at $p = .08$ at $Q = 15$), and for anger at Q values greater than 7 (with a nonsignificant effect at $Q = 11$ and a marginally significant effect at $p = .09$ at $Q = 12$). Similarly, effortful control was significantly related to vertices at Q values greater than 6. Effect sizes for statistically significant effects were generally in the medium range, ranging from $d = .32$ to $d = .42$ for aggression, from $d = .31$ to $d = .45$ for attention problems, from $d = .30$ to $d = .37$ for anger, and from $d = .30$ to $d = .50$ for effortful control. Additionally, the term for school absence was significant at $p < .001$ in each analysis, but the age and sex terms did not reach statistical significance in any analysis.

Finally, it is worth noting that classroom level effects were strong; the average intraclass correlation (ICC; which tests the amount of variance attributable to classroom effects) was .66. According to Kreft (1996), ICC scores greater than .10 indicate significant within-group variance on the outcome variable. Thus, there was substantial variability in breadth scores across classrooms.

*Assessment of Patterns of Change in Vertices*

In the next set of analyses, we considered how various patterns of decline in social breadth across time related to externalizing behaviors and effortful control. In prior research, cluster analysis has been shown to be a valuable tool for differentiating the profiles of subgroups
who differ on a construct across time (e.g., Gorman-Smith, Tolan, Loeber, & Henry, 1998; Hirsch & DuBois, 1991). In the present study, we used a hierarchical clustering procedure to identify distinct subgroups of children with differing patterns of decline in vertex scores from Q = 1 to Q = 15.

We used the average-linkage clustering method, which creates homogeneous clusters by minimizing the mean distance between each case and all other cases in the cluster. Squared Euclidean distances were used as the measure of dissimilarity (Milligan, 1996). Prior to cluster analysis, vertex scores at Q = 1 through Q = 15 were equated by dividing by their respective ranges. This method is recommended by Milligan and Cooper (1988) and is preferable to standardization of variables because it places variables on the same scale without diminishing differences in variances. Examination of the dendrogram and agglomeration coefficients indicated that three groups could be differentiated. The resulting three-cluster solution was validated by conducting a confirmatory cluster analysis (Fisher & Ransom, 1995). Specifically, we used the k-means clustering method (MacQueen, 1967) to conduct a non-hierarchical cluster analysis specifying three groups. We then compared the original cluster solution with the confirmatory cluster solution using the kappa coefficient; kappa = .64, which is in the good range (i.e., .60 < kappa < .80; Landis & Koch, 1977).

The resulting three-cluster solution is depicted in Figure 3. The cluster groups could be differentiated from one another on the basis of slopes as well as mean scores on vertices, and thus are labeled according to mean vertex scores as High (25% of cases), Medium (14% of cases) and Low (61% of cases). A MANOVA comparing cluster groups with vertices at Q values of 1 through 15 yielded a significant multivariate effect, $F(30, 160) = 10.28, p < .001$; significant univariate effects were obtained for vertices at each level of Q, $F$s(2, 94) ranged from 26.23 to 192.74, all $ps < .001$. Post hoc analyses indicated that, at Q = 1, there were no significant
differences in vertices between the high and medium groups, but children in both the high and medium groups interacted with significantly more peers than children in the low group, \( ps < .001 \). At subsequent levels, of \( Q \) (i.e., \( Q = 2 \) through \( Q = 15 \)), children in the high group interacted with significantly more peers than children in both the medium and low groups, and children in the medium group interacted with significantly more peers than children in the low group, all \( ps < .05 \).

To illustrate variations in the slopes of each group, we calculated slopes for \( Q \) values of 1 through 7 separately from slopes for \( Q \) values of 8 through 15. For the medium and low groups, slopes at \( Q = 1 – 7 \) were steep (slopes = -1.9 and -2.0, respectively), but they were much flatter at \( Q = 8 – 15 \) (slopes = -0.5 and -0.2, respectively). For the high group, the slope was modest at both low and high \( Q \) values, -1.1 and -0.9, respectively.

Finally, we tested for sex and age differences in the high, medium, and low groups. There were no significant sex differences. However, we did obtain a significant effect for age, \( F(2, 94) = 4.50, p < .05 \). Younger children were more likely to be in the low group than either the medium or high groups.

**Relations between Vertex Clusters and Externalizing Behaviors**

Mixed model regressions were conducted relating the three cluster groupings of vertex scores over time with our measures of externalizing behaviors. As before, age, sex, and school absence/unavailability were controlled as fixed covariates and classroom was controlled as a random effect. Relations with aggression, attention problems, anger, and effortful control were tested in separate analyses. Significant overall effects for vertex clusters on externalizing behaviors were followed with Tukey post hoc tests with the Kramer adjustment for unequal cell sizes (Tukey, 1973).
The mean scores on the externalizing-related variables for each cluster group are presented in Table 4. The overall effect of vertex cluster group on aggression was marginally significant, $F(2, 77) = 2.86, p = .06$; this effect was due to a trend for the medium group to be more aggressive than the high group, $t(77) = 2.32, p = .06$. For attention problems, the overall effect of vertex cluster group was statistically significant, $F(2, 77) = 3.11, p = .05$. Children in the medium group had significantly higher scores on attention problems than children in the high group, $t(77) = 2.47, p < .05$. A significant overall effect was also obtained for effortful control, $F(2, 78) = 3.31, p < .05$. Children in the medium group were significantly less regulated than children in the high group, $t(78) = -2.55, p < .05$. Finally, there were significant effects of vertex clusters on anger, $F(2, 78) = 5.81, p < .01$. Again, we obtained a significant difference between children in the medium group and children in the high group, with children in the medium group rated as angrier than children in the high group, $t(78) = 2.49, p < .05$. Additionally, we also found that children in the low group were significantly more angry than children in the high group, $t(78) = 3.28, p < .01$. Effect sizes were in the small range for aggression, attention problems, and effortful control ($d$s ranged from .25 to .27) and in the medium range for anger, $d = .36$. The following fixed covariates also reached statistical significance: sex (for models with effortful control, attention problems, and anger) at $p < .01$, age (for the model with effortful control only) at $p < .05$, and school absence/unavailability (for models with effortful control, aggression, and anger) at $p < .05$. The ICCs suggested small to modest classroom effects for models with aggression and attention problems (ICCs were .16 and .32, respectively), but no meaningful classroom effects for models with effortful control and anger (ICCs were .03 and .00, respectively).

Discussion
In this research study, we apply a quantitative procedure, the Q-connectivity method, in a new way and use it to assess children’s social breadth across shorter and longer durations. We also tested the relations of this to indices of externalizing behaviors. Our findings demonstrated that children who exhibited high levels of externalizing behaviors maintained lower levels of social breadth across time. Furthermore, the drop-off in social breadth happened relatively quickly – after just a few interactions with peers. Thus, the findings speak to the extent to which externalizing children maintain interactions with peers over time. Furthermore, the findings contribute to the understanding of the role that social breadth plays in peer relationships and the value of considering time spent with peers. The utility of the Q-connectivity method for future research is also discussed.

The Meaning of Social Breadth

We obtained significant variations in social breadth in this sample of preschoolers, and these variations could be seen at lower and higher values of Q. Thus, there was variability in social breadth across short-lived as well as lasting relationships. From a developmental perspective, we would expect young children to vary considerably in their level of sociability and social competence, which would then influence their ability to form and maintain peer relationships. At this age, children are making the shift from playing alone or along side peers to playing with peers (Rubin & Coplan, 1998). It was no surprise, then, that younger children in our sample had lower social breadth than did older children. As children get older, individual differences in social breadth continue to be apparent and may even increase as some children become increasingly socially sophisticated whereas others exhibit reticent or provocative behaviors that leave them relatively isolated.

For all children, social breadth declined over time – suggesting that the relationships that are maintained for the longest periods of time are more selective than those that are of briefer
durations. However, there were variations in the patterns of decline in social breadth across time. The majority of the children (over 50%) were classified in the low group. They exhibited a pattern of social breadth characterized by relatively low numbers of peer interactions at short durations of time that declined quickly. Thus, these children maintained the fewest peer interactions across time. Because these children tended to be younger than their classmates who were classified in the medium and high groups, they may typify a normative social developmental process in early childhood that is marked by the movement from solitary play behaviors towards increasing engagement in social play with age and social experience. Recall that social breadth was measured in the fall semester. It is possible that assessments of social breadth in the spring semester of preschool (after children had several months of experience in peer group settings) would identify fewer children in the low group. In contrast, the children in both the medium and high groups had greater numbers of interactions with peers over very short durations. These groups could be differentiated by the rates of decline in social breadth, with children in the medium group maintaining fewer interactions over time than children in the high group. Thus, although the children in the medium group appeared, at the outset, to have high social breadth, they were less able to maintain it over time.

Such patterns of social breadth complement the existing literature on children’s peer relationships by highlighting two related, and relatively unstudied, features of peer relationships – namely, the size of children’s individual networks with all other classroom peers and the continuity of their relationships with these peers over time. Thus, social breadth allows one to understand the entire spectrum of children’s relationships with peers, providing a measure of individual children’s embeddedness in the peer group and the variations in this over time. Certainly, with whom children spend their time is important. Peers are not all created equally; rather, different peers afford different opportunities and experiences (Kiesner, Poulin, & Nicotra,
Breadth of Peer Relationships

2003), and the same behavior may evoke different responses from different individuals (Kenny, Mohr, & Levesque, 2001). Thus, social breadth provides a basis for studying individual differences in children’s involvement with various peers.

It is worth noting that we did not find sex differences in social breadth. On the surface, this appears to contradict Waldrop and Halverson’s (1975) finding that 7-year-old boys had more extensive peer relationships than their female peers. However, Waldrop and Halverson operationally defined extensive peer relationships in terms of group (rather than dyadic) play, and prior research has supported the supposition that boys are more likely than girls to play in groups of peers and girls are more likely than boys to play in dyads (Fabes et al., 2003). In the present study, we operationalized social breadth in terms of the number of peers children maintained interactions with over time, but we did not require that interactions with each of these peers were either dyadic or group interactions. Thus, it appears that preschool-aged boys and girls maintain similar-sized social networks, even though they may display differential preferences for group or dyadic play.

Relations between Social Breadth and Externalizing Behavior

The primary goal of this study was to investigate the relations between preschoolers’ own externalizing behavior and the breadth of their peer relationships. This issue is important to understanding the degree to which externalizing children have the potential to negatively influence their peers’ behavior because the greater the social breadth, the more opportunities children have to directly affect their peers (Hanish et al., 2005). We found that several features related to externalizing behavior – aggression, attention problems, anger, and lack of effortful control – were related to social breadth. Thus, the findings were robust across constructs. However, these relations only emerged at moderate to high levels of Q – that is, moderate to high levels of consistent interaction with the same peers. These relations were not evident at
lower levels of Q. Thus, externalizing behaviors were not related to social breadth when such breadth was of limited time. Instead, externalizing behaviors emerged as a correlate of social breadth only when interactions were maintained for longer periods of time. Furthermore, externalizing behaviors were associated with a distinct pattern of change in social breadth (the medium group) in which social breadth was initially very high, but dropped off steeply as Q values increased from 1 to 2 and beyond.

Taken together, these findings suggest that externalizing preschoolers have many short-term relationships with peers (as many as their more socially competent classmates), interacting with most peers in the class on one or just a few occasions. However, many of their relationships appear to disintegrate, leaving fewer stable peer interaction partners. As such, they seem to be less capable than their non-externalizing peers at maintaining a continuity of interactions across time. One avenue for future research is to explore the nature of externalizing children’s interactions with each of their peers. Short-lived interaction patterns may represent attempts to form friendships that result in rejection and ostracism by peers. Persistent interactions may indicate friendships, but they may also be bully-victim relationships or mutual antipathies.

Extant research supports our finding that the relationships of young externalizing children tend to be more short-lived by demonstrating that they are often disliked by non-externalizing peers and their social relationships tend to be more conflictual and of lesser quality (Snyder et al., 1997). These findings should be interpreted within a developmental context. That is, prior studies of older youth have suggested that some externalizing children are well-liked by peers and maintain relationships with relatively socially competent peers whereas others are disliked by most mainstream peers and interact primarily with other externalizing children (Rodkin et al., 2000). However, the extent to which this finding translates to early childhood is unclear, particularly given that the relations between externalizing behaviors and peer acceptance appear
to be stronger for adolescents than for children (Cillessen & Mayeux, 2004; Kiesner & Pastore, 2005). Thus, generalizing these findings to samples of older children and adolescents should be done cautiously.

As has been previously demonstrated, preschoolers, particularly girls, who spent more time with externalizing peers exhibited increases in their own externalizing behaviors even after controlling for initial levels (Hanish et al., 2005). The findings here add to this by demonstrating that externalizing preschoolers interact with the majority of their peers at least once or twice, and they maintain lasting interaction patterns with a smaller number of peers over relatively long periods of time. Thus, there are many potential opportunities for peer contagion to occur. At the same time, though, peer influence processes also occur along dimensions other than aggression, and externalizing children may be influenced by peers to behave in more competent ways. For instance, peers influence engagement in prosocial behavior and academic motivation (Fabes et al., 2005; Kindermann, 1993). The fact that externalizing children have at least a few interactions with most of their peers provides potential opportunities for more positive forms of peer influence, driven by socially competent peers, to occur. This is an important avenue for future research.

*The Q Connectivity Method*

The Q-connectivity method provided a means for conceptualizing and visualizing individual children’s involvement with each of their classmates over time. This method can be used flexibly to quantify aspects of their social interactions, thereby providing a means for addressing questions regarding individual children’s embeddedness in peer groups and variations in this over time. This fundamental aspect of children’s peer relationships has particular relevance to important issues—such as understanding the formation, evolution, and dissolution of peer relationships, peer selection effects, and peer influence processes.
Compared to traditional social network analysis methods, this method has a particularly unique feature. First, network analyses usually provide social maps of the entire classroom (or other social group), collapsing across individual children’s patterns of relationships to create a parsimonious picture of the group as a whole. Thus, the strength of traditional social network analysis involves mapping large-scale connectivity, and not in identifying the patterns of peer relationships at individual levels. As a result, individual children’s patterns of peer affiliations beyond the subgroup are lost. For example, only those peers who meet the minimum criteria to be included in a group are identified as interactional partners. Relationships with peers outside of the network cannot be easily identified; thus, little is learned about the relationships of isolates (who are not designated as a member of a subgroup). In this case, however, we obtained data that allowed us to represent the persistence of each child’s relationships with all other peers over the course of a semester. Thus, we were able to map each child’s entire social portfolio.

Future Directions

We obtained relatively strong classroom effects, which suggests that one or more aspects of the classroom environment contribute to children’s socialization patterns. We did not have a large enough sample of classrooms to adequately test for classroom effects in this study, however, it is clear that such work is needed. Classroom characteristics may affect social breadth in numerous ways. Perhaps the aggregation of particular types of peers (e.g., classrooms with larger numbers of externalizing children) creates variations in socialization patterns. Indeed, as Stormshak et al., (1999) have demonstrated, social preference scores in first grade classrooms depended upon the extent to which classmates were aggressive, with aggressive children having higher social preference scores in aggressive classrooms and lower social preference scores in nonaggressive classrooms. Additionally, we have previously reported classroom level effects on patterns of peer victimization in preschool classrooms using a different sample of young children.
(Hanish, Ryan, Martin, & Fabes, 2005). Alternatively, teachers’ behaviors and child management styles may create different patterns of socialization from one classroom to another. For instance, the extent to which teachers take an active role in structuring children’s peer relationships may influence socialization patterns (Howes, Hamilton, & Matheson, 1994). Future research that dissects the role of classrooms is needed to better understand this contextual contributor to social breadth.

We focused only on one aspect of Q connectivity – namely, the number of vertices at levels of Q (which we called social breadth). Although it is beyond the scope of the current paper, Q-connectivity has the potential to offer a variety of informative measures of interactional patterns; density, interconnectivity, rate of change, maximum value of Q, and a variety of vector measures across Q are examples of just a few measures that can be calculated using this method. Q-connectivity analyses also may be undertaken to reveal latent structures in social interactional patterns. Additionally, the use of graphics as a language for examining social interactional patterns over time may make a powerful contribution and may open up new lines of systemic research (Legrand, 2002).

Conclusions

The introduction of the Q-connectivity method allows for an expanded ability to assess peer interactions and thus has the potential to inform researchers about how peer influences may occur within social networks. From the perspective of understanding deviant peer influences in early childhood, this study contributes to the emergence of knowledge regarding the extent to which young externalizing children engage with their peers, thereby providing the opportunity to socialize peers’ aggressive behavior. Because of the critical role that deviant peers play in the development of delinquency in adolescence, a thorough understanding of the early developmental precursors to that process is greatly needed.
References


Author Notes

Laura D. Hanish, Carol Lynn Martin, and Richard A. Fabes, School of Social and Family Dynamics, Arizona State University; Helene Barcelo, Department of Mathematics and Statistics, Arizona State University.

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Please address correspondence to Laura Hanish at Arizona State University, School of Social and Family Dynamics, Program in Family and Human Development, Box 873701, Tempe, AZ, 85287-3701. E-mail: Laura.Hanish@asu.edu.
Footnotes

1 Edges are calculated when a target child is observed to interact with two peers on the same day. Edges and other quantitative measures that are not relevant to the present study can be calculated from the graphs. Please contact the authors for more information about these.

2 In the present study, we operationally define the term “relationship” in terms of children’s social interactions.

3 Vertex scores could be calculated through $Q = 46$ in the present sample (i.e., no child was observed to interact with the same peer on more than 46 days during the semester). These data are not presented here because of limited variability at the greatest $Q$ levels; however, they are available from the authors.

4 We also tested for a significant relation between family income and vertices. There were significant correlations at $Q$ values of 4 through 10, average $r(70) = -.27, p < .05$, but this was reduced to zero once classroom was controlled, suggesting that the significant effect for income was indicative of classroom differences. Indeed, family income varied significantly by classroom, $F(5, 64) = 6.70, p < .001$.

5 We also ran the analyses with an interaction term for sex to test for potential moderation by sex. However, none of the interaction terms reached statistical significance.

6 Because deriving the clusters’ initial centroids randomly can create distortions in the classification scheme in a non-hierarchical cluster analysis (Milligan & Sokol, 1980), we specified start values based on the results of a second hierarchical cluster analysis conducted using Ward’s clustering method (1963).
Table 1

*Descriptive Statistics for Vertices at Q = 1 Through Q = 15 (N = 97)*

<table>
<thead>
<tr>
<th>Q</th>
<th>Minimum</th>
<th>Maximum</th>
<th>M</th>
<th>S</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>19</td>
<td>16.</td>
<td>2</td>
<td>-1.4</td>
<td>3.3</td>
</tr>
<tr>
<td>2</td>
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<td>13.</td>
<td>4</td>
<td>-0.7</td>
<td>0.3</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>19</td>
<td>11.</td>
<td>5</td>
<td>-0.2</td>
<td>-0.8</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>19</td>
<td>9.5</td>
<td>5</td>
<td>0.2</td>
<td>-1.0</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>19</td>
<td>7.8</td>
<td>5</td>
<td>0.4</td>
<td>-0.9</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>18</td>
<td>6.6</td>
<td>4</td>
<td>0.6</td>
<td>-0.6</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>17</td>
<td>5.5</td>
<td>4</td>
<td>0.8</td>
<td>-0.2</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>16</td>
<td>4.5</td>
<td>3</td>
<td>0.9</td>
<td>0.0</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>16</td>
<td>3.8</td>
<td>3</td>
<td>1.2</td>
<td>1.1</td>
</tr>
<tr>
<td>1</td>
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<td>14</td>
<td>3.2</td>
<td>3</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>11</td>
<td>2.8</td>
<td>2</td>
<td>1.1</td>
<td>0.9</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>11</td>
<td>2.3</td>
<td>2</td>
<td>1.3</td>
<td>1.5</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>9</td>
<td>2.0</td>
<td>2</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>9</td>
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<td>8</td>
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<td>1</td>
<td>1.5</td>
<td>2.4</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>8</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

*Note.* Q indicates the number of days in which a child was observed to be interacting with one or more of the same peers.
Table 2

Descriptive Statistics for Externalizing-related Variables (N = 97)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Minimum</th>
<th>Maximum</th>
<th>M</th>
<th>S</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggression</td>
<td>0.0</td>
<td>36.0</td>
<td>6.9</td>
<td>1.5</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Attention Problems</td>
<td>0.0</td>
<td>14.0</td>
<td>2.3</td>
<td>1.5</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Anger</td>
<td>1.6</td>
<td>6.9</td>
<td>3.1</td>
<td>0.3</td>
<td>-1.0</td>
<td></td>
</tr>
<tr>
<td>Effortful Control</td>
<td>1.8</td>
<td>6.6</td>
<td>4.1</td>
<td>-0.5</td>
<td>-0.6</td>
<td></td>
</tr>
</tbody>
</table>
Table 3

Relations between Externalizing-related Behaviors and Vertex Scores at $Q=1$ through $Q=15$

<table>
<thead>
<tr>
<th>Q</th>
<th>Aggression</th>
<th>Attention Problems</th>
<th>Anger</th>
<th>Effortful Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Est. (SE)</td>
<td>t</td>
<td>Est. (SE)</td>
<td>t</td>
</tr>
<tr>
<td>1</td>
<td>-0.00 (.02)</td>
<td>-0.14</td>
<td>-0.01 (.06)</td>
<td>-0.20</td>
</tr>
<tr>
<td>2</td>
<td>-0.01 (.03)</td>
<td>-0.38</td>
<td>-0.05 (.09)</td>
<td>-0.56</td>
</tr>
<tr>
<td>3</td>
<td>-0.01 (.03)</td>
<td>-0.43</td>
<td>-0.08 (.09)</td>
<td>-0.88</td>
</tr>
<tr>
<td>4</td>
<td>0.01 (.03)</td>
<td>0.22</td>
<td>0.01 (.09)</td>
<td>0.06</td>
</tr>
<tr>
<td>5</td>
<td>-0.03 (.03)</td>
<td>-0.88</td>
<td>-0.12 (.08)</td>
<td>-1.43</td>
</tr>
<tr>
<td>6</td>
<td>-0.03 (.03)</td>
<td>-1.32</td>
<td>-0.15 (.07)</td>
<td>-2.03*</td>
</tr>
<tr>
<td>7</td>
<td>-0.05 (.03)</td>
<td>-1.95†</td>
<td>-0.18 (.07)</td>
<td>-2.48*</td>
</tr>
<tr>
<td>8</td>
<td>-0.04 (.02)</td>
<td>-1.87†</td>
<td>-0.16 (.06)</td>
<td>-2.48*</td>
</tr>
<tr>
<td>9</td>
<td>-0.06 (.02)</td>
<td>-2.49*</td>
<td>-0.18 (.06)</td>
<td>-2.86**</td>
</tr>
<tr>
<td>10</td>
<td>-0.06 (.02)</td>
<td>-2.75**</td>
<td>-0.17 (.06)</td>
<td>-3.00**</td>
</tr>
</tbody>
</table>

Note. Age, sex, and school absences were controlled as fixed effects, and classroom was controlled as a random effect. Degrees of freedom are 1, 78 for analyses with aggression and attention problems and 1, 79 for analyses with anger and effortful control.

† $p < .10$. * $p < .05$. ** $p < .01$. 


Table 4

*Mean Scores on Externalizing-related Behaviors for Vertex Cluster Groups*

<table>
<thead>
<tr>
<th></th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggression</td>
<td>7.5 (2.0)</td>
<td>9.5 (3.1)</td>
<td>2.0 (2.9)</td>
</tr>
<tr>
<td>Attention Problems</td>
<td>2.6 (1.0)</td>
<td>4.2 (1.3)</td>
<td>1.3 (1.3)</td>
</tr>
<tr>
<td>Effortful Control</td>
<td>4.6 (0.2)</td>
<td>4.0 (0.3)</td>
<td>4.9 (0.3)</td>
</tr>
<tr>
<td>Anger</td>
<td>4.2 (0.2)</td>
<td>4.2 (0.4)</td>
<td>3.1 (0.3)</td>
</tr>
</tbody>
</table>

*Note.* Means are adjusted for age, sex, school absences, and classroom. Standard errors are presented in parentheses. Means in the same row that share subscripts are significantly different at *p* < .05.

* The means for the medium and high groups are marginally different at *p* < .06.
Figure Captions

*Figure 1.* Graphs for Boy 709 at $Q = 1$ through $Q = 11$.

*Figure 2.* Graphs for Boy 739 at $Q = 1$ through $Q = 20$.

*Figure 3.* Vertex scores for three cluster groups at $Q = 1$ through $Q = 15$. 
Figure 1

Note. Q indicates the number of days that the target child was observed to interact with the same peer.
Figure 2

Q = 1  Q = 2  Q = 3  Q = 4

Q = 5  Q = 6  Q = 7  Q = 8

Q = 9  Q = 10  Q = 11  Q = 12

Q = 13  Q = 14  Q = 15  Q = 16

Q = 17  Q = 18  Q = 19  Q = 20

Note. Q indicates the number of days that the target child was observed to interact with the same peer.
Figure 3