The Evolution of Youth Friendship Networks from 6th to 12th Grade:

School Transitions, Popularity and Centrality*

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Friendships serve crucial functions among the everyday lives of young people. Strong personal ties aid in improving adolescents' mental health (Ueno 2005), better their academic outcomes (Vaquera and Kao 2008), and shape their prosocial and antisocial behavior (Rodkin and Hanish 2007). Broad, social network patterns matter, as well. Social networks provide the environmental context that influences the stability and quality of youth friendships and relationships (e.g., Felmlee 2001; Flynn, Felmlee, and Conger 2014; Umberson, Crosnoe, and Reczek 2010). Yet, with few exceptions (e.g., Moody et al. 2011), we know little about the ways in which these crucial, linked bonds evolve and change, especially over extended intervals of time. The bulk of research on young people's friendship networks focuses instead on cross-sectional data based on small samples, or on relatively short, panel studies. Literature reviews and meta-analyses call for more longitudinal studies and designs in this area (Newcomb and Bagwell 1995, Poulin and Chan 2010). One of the main purposes of this study, therefore, is to examine changes in youth friendship networks over a relatively lengthy period.

The life course processes of aging and maturation, as well as fluctuations in contextual factors, are apt to contribute to noteworthy alterations in adolescent friendship patterns over time, patterns that may not be readily visible on the basis of one or two data points. In addition, almost all young people experience noteworthy life transitions when they matriculate from elementary school to middle school and then from middle to high school. These transitions pose noteworthy challenges that are likely to influence substantially their friendship patterns. Given the salience of friendships for multiple youth outcomes, examining shifts in adolescent social

networks constitutes a crucial task for research. A better understanding of such changes in friendship patterns can help to inform developmental life course theories and provide additional knowledge to support students as they progress through adolescence.

The first purpose of this study is to document changes in youth friendship networks over six years, beginning in sixth grade and ending in twelfth. Furthermore, building on a life course perspective that emphasizes the role of life transitions, we examine the degree to which two life transitions for young people, those of departing elementary school to attend middle school, as well as leaving middle school to attend high school, influence their friendship networks. Our primary focus will be on changes in two central social network dimensions, those of in-degree, or popularity, and network centrality. We use data from the Promoting School-Community Partnerships to Enhance Resilience (PROSPER) study, which yields a uniquely large sample of over 50 adolescent friendship networks. We begin with an overview of relevant literature.

Adolescent Friendship Networks

Friendships provide numerous benefits for adolescents. These strong ties afford young people a chance to find independence from their familial relationships, deal with the stress and pressures of growing up, and construct or imitate routines they learn from adults (Bagwell and Schmidt 2011; Giordano 2003; Umberson, Crosnoe, and Reczek 2010). The social networks of adolescents, furthermore, provide the context for the socialization of a range of developmental outcomes, including academic, mental health, supportive behavior and more problematic behavior (Rodkin and Hanish 2007). Thus, the number of close friendships and the relative stability of those ties are likely to have lasting influences on young people.

Recent research underlines the importance of social network analysis in understanding the processes influencing adolescent friendships (Cairns et al. 1995; Faris and Felmlee 2011;

Flynn, Felmlee, and Conger 2014; McFarland et al. 2014; Rodkin and Hanish 2007; Temkin et al. 2015). These processes include the effect of other social actors (Flynn, Felmlee, and Conger 2014; Umberson, Crosnoe, and Reczek 2010), the centrality of actors within their network (e.g., Calvo-Armengol, Patacchini, and Zenou 2009), and the broad school context (McFarland et al. 2014). For example, the multiple connections of parents, romantic partners, and peers all shape the stability and quality of adolescent friendships (Flynn, Felmlee, and Conger 2014). Centrality in adolescent friendship networks also relates significantly to academic outcomes (Calvo-Armengol, Patacchini, and Zenou 2009) and school aggression (Faris and Felmlee 2011). Adolescents' health influences their friendship networks, as well, with those in poor health, as compared to those in good health, located in less central network positions and in smaller, local network structures (Haas, Schaefer, and Kornienko 2010).

Popularity represents one particularly noteworthy aspect of friendship networks and receives considerable attention in the literature. There are two broad ways of conceptualizing and measuring popularity in network research (e.g., McElhaney, Antonishak, and Allen 2008): perceived popularity and sociometric popularity. Perceived popularity measures how individual students see their own position within the school setting. Sociometric popularity measures how well-liked an adolescent is by his or her peers by counting the number of friendship nominations received from other students (network in-degree). Perceived popularity remains useful when discussing the ways in which students' own perceptions of social acceptance may emanate from sources other than school peers, such as friends outside the school (McElhaney, Antonishak, and Allen 2008). Sociometric popularity, on the other hand, aids in placing an adolescent within the social context of his or her school setting. Moreover, high sociometric popularity is associated generally with several outcomes, such as prosocial behaviors (Allen et al. 2005; McElhaney,

Antonishak, and Allen 2008; Moody et al. 2011), low levels of aggression (e.g., Faris and Felmlee 2014), and friendship stability over time (Bowker 2004; McElhaney, Antonishak, and Allen 2008; Moody et al. 2011). Here we focus on measures of individual, sociometric popularity, or social network indegree, which is also used as a measure of social network centrality. In addition we examine two other measures of network centrality, betweeness and Bonacich.

Life Course Perspective

In addition to employing a social network framework to examine changes in adolescent friendships, we borrow from a life course perspective on social processes to better understand the ways in which young people's relationships evolve over a sequence of several school years. Benner (2011) emphasizes the importance of using a life course perspective to contextualize and understand transitions in the American educational system, noting that such an approach connects individual patterns to the broader social context. Two life course concepts remain particularly pertinent to our topic, in particular those of "linked lives" and "life transitions." According to the fundamental, life course principle of "linked lives" (Elder 1994), individuals' experiences are lived interdependently within a set of shared relationships that are embedded in personal networks. One major, normative life event for youth concerns puberty, and a major goal during that life stage is the establishment of social ties outside the family, and in particular, those of friendship (Wrzus et al. 2012). Here our focus remains on the linked lives of peers as expressed in their school friendship ties.

According to Kahn and Antonucci (1980), the concept of "linked lives" can be thought of as a convoy that evolves over time and contains valued resources for peoples' well-being and functioning. This notion of a network convoy is particularly informative for theories of social

network change; the inner-core of the convoy is likely to remain relatively consistent (e.g., family and close friends), whereas more peripheral relationships become less stable (Wrzus et al. 2012).

A second core concept of the life course paradigm that is relevant to our research is that of "life transitions." Transitions, or specific life changing events such as marriage, employment and school changes, shift over relatively short time ranges and are located within life course trajectories (Elder 1985). The life course does not simply proceed in a linear fashion along with aging, but responds to turning points that can abruptly alter individuals' experiences and outcomes. A normative life transition of concern to our topic involves the shift from one level of schooling to another, that is matriculation from either primary school to middle school or from middle school to high school.

Friendship Over Time

The social ties of young people likely shift considerably over time for a number reasons. First, children and youth face numerous cognitive, behavioral, and emotional, developmental milestones during the school years, all of which are apt to influence their close relationships. In addition, contextual factors likely foster further adjustments to the friendships of children and teens, such as shifts in the composition of school classes from year to year, which can minimize the time children have to interact with the same, school friends over time. Given that extracurricular activities promote friendship formation (Schaefer et al. 2011), changes in sports and other school activities are apt to result in the termination of friendships originating from old activities, and the initiation of novel ties associated with the new ones. High levels of geographic mobility in the U.S. also means that a number of children and adolescents shift schools entirely, which entails a major curtailment and alteration of individuals' network of friendship ties (South

and Haynie 2004).

Empirical studies of youth friendships tend to focus primarily on cross-sectional data and minimize the evolution of such relationships over the course of the school year and beyond (Newcomb and Bagwell 1995). Nonetheless, a key measure in recent studies that do examine temporal shifts in adolescents' friendships is friendship stability. Many studies document considerable instability in adolescent friendship networks (e.g., Berndt and Hawkins 1985; Bowker 2004; Branje et al. 2007; Chan and Poulin 2007; Güroğlu et al. 2012; Hartl et al. 2015; McElhaney, Antonishak, and Allen 2008; Parker and Seal 1996; Poulin and Chan 2010; Selfhout, Branje, and Meeus 2008). Several investigations that follow friendships over the school year, for example, find that approximately 50% of friendships remain the same (e.g., Berndt and Hoyle 1985; Bowker 2004; Değirmencioğlu et al., 1998). Those rare projects that examine friendships over relatively extensive time periods document remarkably high levels of volatility. For instance, Moody et al. (2011) followed young people from sixth to ninth grade, using a subsample from the same set of schools used in the current investigation; they documented that only 15% (one in seven) of friendship nominations made by sixth graders lasted until ninth grade. Another long-term study found that almost all friendships changed between seventh and twelfth grade, with only 1% remaining stable (Hartl et al. 2015). Not unexpectedly, rates of friendship changes increase as the intervals of time in studies lengthen.

Given the elevated levels of friendship instability during the school years, it may not be surprising that research tends to find that youth report fewer friendships over time (e.g., Berndt, Hawkins, and Jiao 1999; Hardy, Bukowski, and Sippola 2002; Aikins, Bierman, and Parker 2005; Kingery, Erdley, and Marshall 2011; Temkin et al. 2015). A number of other, related trends occur over time for adolescent friendships. Friendships that are not reciprocal, that is those

not reported by both members, tend to be less stable over time (Berndt and Keefe 1996; Değirmencioğlu et al. 1998; Hardy, Bukowski, and Sippola 2002; Moody et al. 2011; Sentse et al. 2014). Furthermore, older youth tend to lose more friendships than those who are younger, for example, with eighth graders losing more friends than they gained (Berndt and Hoyle, 1985). Friendship fluctuation decreases over time (Thompson and Horrocks 1947, Bowker 2004, Branje et al. 2007), on the other hand, and friends who have more in common are more likely to last (Hafen et al. 2011, Hartl et al. 2015, Selfhout et al. 2009). Finally, as students age, the quality of their friendships increase (Berndt and Hawkins 1985; Bowker 2004; Selfhout, Branje, and Meeus 2008), which suggests that although quantity may shrink, the value of the existing friendships may improve.

Given the trends in the existing literature, and our lengthy time span, our first hypothesis is that sociometric popularity, that is friendship network indegree, will decrease over the school years from sixth grade until twelfth grade. To the best of our knowledge, this time span represents one of the longest examined in current research.

H1: Friendship network indegree, in addition to betweeness centrality and Bonacich centrality, will decrease over time, from sixth grade until twelfth grade.

The Transition from Middle to High School

Normative, school transitions between levels of the U.S. educational trajectory represent noteworthy and often challenging phases of childhood and adolescence. The process of changing schools from elementary school to middle school, or from middle to high school, means, for example, having to adapt to new environments and expectations that can have broad and lasting consequences. Transitions to another level of schooling, and in particular the shift to high school, typically entail increasingly difficult academic challenges. In most cases, moving school levels

also means that young people are placed within classrooms with many, if not all, new classmates, in addition to experiencing different teachers, guidance counselors, coaches, club mentors, and support staff. More generally, school transitions inevitably involve changes from familiar and routine environments to those that are unfamiliar and may seem unpredictable (Caspi and Moffitt 1993).

Extensive research considers the effects of school transitions on outcomes for children and adolescents. The majority of studies focus on the transition from elementary school to middle school (Benner 2011), often focusing on a shift between sixth and seventh grade. Several scholars argue that this transition is particularly demanding (Barber & Olsen 2004; Blyth, Simmons, and Carlton-Ford 1983; McDougall and Hymel 1998). Yet the shift to high school can be difficult as well, and it has important ramifications for young people (Benner 2011). Therefore, here we consider both the effects of the transition from elementary school to middle and that from middle to high school.

Research often reports academic problems associated with school transitions for children and adolescents. For example, studies quite consistently document that students' academic grades and outcomes decline, especially for the change from middle to high school (Blyth, Simmons, and Carlton-Ford 1983; Kingery, Erdley, and Marshall 2011; Seidman el al. 1994). Declines also are observed for students' school engagement, with adolescents becoming less active in extracurricular activities after high school entry (Seidman et al. 1996), and teachers report students as being less academically engaged (Roderick 2003).

Fewer studies consider adolescent socioemotional adjustment over the course of school transitions. Those that do, however, tend to document that time period as taxing (Benner 2011). For example, youth exhibit higher levels of anxiety and loneliness over the transition from

middle school to high school, with loneliness increasing across the initial years of high school (Benner and Graham 2009). This transition also is associated with higher levels of depression (e.g., Newman et al. 2007) and lower levels of self-esteem (Barber and Olsen 2004; Blyth, Simmons, and Carlton-Ford 1983; Hirsch and Rapkin 1987; Seidman et al. 1994; Wigfield et al. 2010).

Certain studies examine the effects on friendships of normative school transitions, and a few find mixed results or no negative effect on socio-emotional functioning and/or friendship structure (e.g., Marshall 2011; Temkin et al. 2015; Wallis and Barrett 1998). Yet the bulk of research typically reports largely negative consequences of such shifts. For example, transitions from multiple feeder schools to a single higher level school are associated with less connected friendship networks, increased social distance and segregation in friendships, as well as higher friendship instability (Temkin et al. 2015). Other studies find fewer or less stable friendships following changes between levels of schooling (Berndt and Hawkins 1985; Güroğlu et al. 2012) and high levels of shifts in best friends (Aikins, Bierman, and Parker 2005). Nominations of reciprocated friendships, as well as those of old friendships, decrease over school changes, as well (Hardy, Bukowski, and Sippola 2002). Moreover, multiple school transitions are particularly damaging to students, as compared to school changes in single-transition districts (Blyth, Simmons, and Carlton-Ford 1983; Crockett et al. 1989; Temkin et al. 2015).

In a review of the literature, Benner (2011) stresses the importance of a longer longitudinal period (beyond the year before and after the transition) to understand the impact of school transitions over time. Furthermore, several scholars (Barber & Olsen 2004; Blyth, Simmons, and Carlton-Ford 1983; Wallis and Barrett 1998; Wigfield et al. 1991) claim that most adolescents' social declines are generally limited to the period directly after the transition and

these behaviors may be mostly recovered or gone a year later. The effects of school transitions could be misrepresented without following students for lengthy periods of time.

Our purpose in this study, therefore, is to examine the effects of school transitions on the friendship networks of students for a lengthy period of time that begins in sixth6th grade and continues through the senior year of high school. This extensive time period will allow us to examine the extent to which the influence of normative school transitions tends to be long-lasting. Based on both theory regarding life transitions and previous research findings, we hypothesize that school transitions, both those from sixth to seventh and those from eighth to ninth, will have negative ramifications both for friendship indegree, or popularity, and friendship centralization. Note that these two patterns of transitioning represent the modal arrangements in our data set. Of the school districts in our sample, 84.31% transition from middle to high school between eighth and ninth grade and 35.29% transition from elementary to middle school between sixth and seventh grade.

H2: Friendship indegree and friendship centralization both will decline following normative school transitions, and we expect these effects to last longer than one academic year.

Data and Methods:

Sample:

For our analysis we are considering data on approximately 13,214 students who attended middle and/or high schools within one of 28 small public school districts participating in the Promoting School-Community Partnerships to Enhance Resilience (PROSPER) study. Half of the school districts are located in Iowa and the other half are in Pennsylvania. Participating districts were required to have between 1,300 and 5,200 students, 15% of which must have been

eligible for free or reduced lunch. All school districts were located in rural or semi-rural communities with populations ranging from 7,000 to 45,000. Half of the schools in the study were randomly assigned to participate in both family- and school-based substance abuse prevention programs during respondents' sixth and seventh grade years.

Data were collected for two cohorts: students entering the sixth grade in 2002 and those entering in 2003. Self-administered surveys were distributed to students during the fall and spring semesters of their sixth grade year and during the spring semesters of their seventh through twelfth grade years, yielding eight waves of data that each include over 11,000 students. Response rates were generally high over all eight waves, varying from 86-90%, as were participant retention rates, with students participating in a mean of 4.18 waves in the survey. Of the students who participated, 93.9% provided a maximum of seven friendship nominations. Approximately 83.0% of the nominations were successfully tied to other students participating in the study, while 14.7% of the nominations appeared to be students who were either in another grade level or attended a different school. Coders were unable to match 1.9% of names because there existed multiple possible matches and deemed 0.4% of names to be implausible (i.e. names of celebrities). For the purpose of this study, we only consider within-community and within-grade friendship nominations. Furthermore, we exclude five networks from our analysis due to irregularities (e.g. one school was affected by a fire), resulting in a sample of 51 friendship networks.

Definition of Variables:

In each wave of the study, students were asked, "Who are your best and closest friends in your grade?" They were permitted to nominate up to two "best friends" and as many as five "other close friends," allowing each student to nominate a maximum of seven peers. As

discussed previously, we only consider nominations of within-community and within-grade friends, from which we constructed a total of 51 global friendship networks.

School transitions are one of the independent variables of interest in our study. Here we are only referring to normative transitions, or the expected transitions that students generally experience during childhood and adolescence. Such transitions include the shift from attending elementary to middle school and that from middle to high school.

Youth in all networks in our study experienced at least one school transition during the course of the study and six experienced two transitions. However, the timing of these transitions varied across the 26 communities: 35.3% underwent school transitions between sixth and seventh grade, 84.3% transitioned between eighth and ninth grade, and 7.8% did so between ninth and tenth grade. To specifically test for the effect of school transitions, we include two binary variables in our models, one to measure the effect of transitions between sixth and seventh grade and one to measure the effect of transitions between eighth and ninth grade (1 = experienced transition). Due to small sample sizes, we did not include a binary variable modeling transitions experienced between ninth and tenth grade.

We add several control variables that could be associated with an individual's tendencies to both nominate friends and receive nominations from their peers. A binary variable was included for state of school's location (0 = Pennsylvania, 1 = Iowa), cohort (1 = Cohort 1), gender (1= girl), race (1 = white), free/reduced lunch status (1 = receives free/reduced lunch), and living with both biological parents (1 = lives with both). We also included a measure of school adjustment and bonding (measured using 8 survey items, with a higher score indicating greater adjustment/bonding), delinquency (measured using 12 survey items, with a higher score indicating higher delinquency), and school performance (1 = mostly F's, 5 = mostly A's).

Centrality Measures and Plan of Analysis:

We measure individual students' positions in their social networks by examining three measures of individual centrality: indegree, Bonacich, and betweenness centrality. We first calculated indegree, or the number of friendship nominations each student receives from his or her peers (Wasserman and Faust 1994). Even though students could only nominate a maximum of seven friends, there was no limit to the number of nominations a student could receive. Previous research often uses indegree as a measure of individual popularity (Moody et al. 2011, Valente et al. 2005).

Our second network measure, Bonacich centrality, not only considers the number of nominations received by a student; it also considers how popular these students are in the overall network. A student with high Bonacich centrality would not only receive multiple friendship nominations, but these nominations would be from other, highly popular students.

Finally, we consider betweenness centrality, a measure calculated by first summing the total number of geodesics (i.e. shortest paths that connect all pairs of students). Then, for each focal student we calculate the percent of geodesics on which he or she is situated. Students with high betweenness play a crucial role in connecting a friendship network. They tend to operate as bridges, linking parts of the network that have infrequent contact.

To test our research questions regarding the relationship between school transitions and individual centrality, we apply multi-level models (MLMs) to account for the nested structure of our data. In our sample, respondents belonged to one of two cohorts that were nested within twenty-six school districts. To account for this hierarchal structure, we employ three-level MLMs where the first level represents the student, the second represents the cohort, and the third represents the school district. Three-level MLMs are similar to standard regression models

except they allow intercepts and slopes in the individual-level model to vary by the groupings at higher levels (Hox 2010). Furthermore, since MLMs allow us to test for cross-level interactions, they enable us to test whether there are gender differences in the relationship between transitions and centrality. In running our MLMs, we used multiple imputation (using multivariate normal regression imputation, or mvn) to account for missing data.

Results:

Descriptive statistics:

There are slightly more girls in the sample than boys, and there is relatively little racial diversity, 84.9% of students are white (see Table 1). Over all eight waves, the average number of friendship nominations received by each student was 3.343, yet this measure varied from 0 to 20 friendship nominations. Average Bonacich centrality over the eight waves was 0.763, where a measure of 1 approximately corresponds to an individual who does not have particularly high or low centrality. Finally, average individual betweenness centrality was 0.017, indicating that students were located on an average of 1.7% of the shortest paths in their network during the course of the study.

Individual Centrality Over Time:

After considering how average individual centrality varies across the eight waves of our study, it is clear that average individual centrality tends to reach its maximum in early adolescence (See Figure 1).[1] Average betweenness reaches its peak during sixth grade (0.023), indegree does so in seventh (4.043), and Bonacich in eighth (0.813). After reaching this

[1] Due to the different ranges of each centrality measure (see Table 1), we normalize each measure of centrality and then scale the normalized values so that their minimum and maximum reflect those of indegree. This normalization technique is only used in Figure 1 in order to better visualize how the overall trends in individual centrality relate to one another. When interpreting our findings, we will refer to the actual averages of each centrality measure which are presented in Table 2.

maximum, average centrality declines steadily until twelfth grade when all three centrality measures reach their minimum value (betweenness = 0.010, indegree = 2.226, Bonacich = 0.638).

To further illustrate how individual centrality varies over time, we present illustrations of two network graphs in Figure 2. Both graphs illustrate friendship networks from a small school in our sample at two different time points. In each graph, circles represent students, lines represent friendship ties, and arrows indicate the direction of each friendship nomination. Circles have been sized to reflect indegree, so that larger circles are more popular. Students' locations in the friendship network visualization have been locked in place, meaning that a student's location in the sixth grade graph is the same as his or her location in the twelfth grade graph. Over time, there are two core friendship groups that remain relatively intact: one is located on the left half of the graph and the other is located on the right side. In sixth grade, each group appears to be particularly well connected; students tend to be friends with many of peers in their same group. However, in twelfth grade, each group appears to be substantially less connected than they were during the first wave of the study. There are fewer friendship ties present in twelfth grade and the two larger groups appear to be further partitioned into sub-groups.

School Transitions and Centrality:

To better understand why this decline in centrality occurs during late adolescence, we further considered the role played by school transitions. Using multi-level regression models, we find that in the year following a normative school transition, students are expected to receive fewer friendship nominations. Students attending schools that experience a transition between sixth and seventh grade receive fewer friendship nominations in their seventh grade, the year immediately following the transition (b = -0.242, $p < 0.10$) (see Table 3, Model 1). In other

words, a student who transitions from elementary to middle school between sixth and seventh grade received roughly 0.24 fewer nominations in their seventh grade year compared to those who did not make such a transition. Similarly, students who transition between eighth and ninth grade also receive fewer friendship nominations in ninth grade than do their peers who do not transition at this time (b = -0.275, $p < 0.001$) (see Table 4, Model 1). Furthermore, there is no significant gender difference in the effect of transitions on centrality. For both the seventh and ninth grade models, the interactions between gender and experiencing a transition were not significant (see Table 3, Model 2 and Table 4, Model 2).

The relationships between changing schools between eighth and ninth grade and average individual indegree throughout adolescence can be visualized in Figure 3. During sixth through eighth grade, average indegree tends to be similar among all students; the difference in mean indegree for transitioning and non-transitioning schools is not statistically significant, as confirmed by a two-tailed *t*-test. However, students who change schools between eighth and ninth grade have significantly lower average indegree in ninth grade, the year directly following the transition. With the exception of tenth grade, this pattern continues for all later grades, suggesting that normative school transitions have long-term consequences on friendship networks and individual popularity. Changing schools between eighth and ninth grade not only reduces centrality in the year directly following the transition, it continues to be negatively associated with centrality throughout students' high school experiences.

Several control variables are also significant and in the expected direction. In seventh and ninth grade, both girls and white students received more nominations than boys and non-white students. In both years, those who received free or reduced lunch tended to be less popular. Living with both biological parents and earning higher grades were significantly associated with

higher indegree. Interestingly, higher delinquency scores were associated with increased popularity in seventh grade, but decreased popularity in ninth grade. Finally, students from larger schools tended to receive fewer nominations.

Supplemental Analyses:

In analyses not shown here, we explored factors that, in addition to school transitions, might account for the decline in measures of network popularity and centrality. The first of these concerns romantic relationships, which become increasingly common during late adolescence. Dating individuals often report smaller friendship networks, a process known as dyadic withdrawal (Johnson and Leslie 1982). However, this phenomenon does not appear to explain the decline in network popularity and centrality observed in our sample. While the proportion of students in dating relationships increases in the later waves of our data, respondents in romantic relationships continually make between 21 to 42% more friendship nominations than their single peers. In other words, romantic ties do not appear to supplant friendship connections over time, and therefore, cannot easily account for our finding of diminishing friendship centrality.

A second factor that could be influencing our results has to do with friendships made with peers in other grades. Since the current analysis only considered within-grade friendship networks, one could argue that an increase in out-of-grade friendships explains the falloff in individual popularity and centrality during late adolescence. Yet, our supplementary analyses suggest that the observed weakening in popularity and centrality cannot be accounted for by changes in out-of-grade friendship. In the last five waves of the survey, students were asked to report the number of friends they had outside of their grade. In eighth grade, respondents reported an average of 5.81 out-of-grade friends and by twelfth grade, this average did not increase, but instead decreased slightly to 5.67 friends. The number of friendship nominations

made to others in different grades did not expand over the secondary school years, in other words, which suggests that such ties are not replacing those made within the same grade.[2]

Discussion

In sum, our findings highlight the importance of examining the friendship structure of youth over an extended time period. First, we see dramatic changes in the overall patterns of friendship networks during the six years between sixth and twelfth grades. All our measures of network centrality demonstrate a remarkable decline in size over time, subsequent to peaks that occur during middle school. Our measure of average network popularity or indegree, for example, exhibits an initial increase until it crests in seventh grade, after which point it decreases steadily until it reaches its lowest level in twelfth grade. Bonacich network centrality displays an almost identical pattern of an initial increase until eighth grade, with a subsequent decay that is almost linear. Betweenness centrality also presents a downward slope, and one that begins immediately after the Fall of sixth grade. Steady decreases in network centrality following middle school occur whether or not students experience school transitions. Moreover, multi-level models further confirm that transitions consistently have a negative impact on adolescents' friendship nominations.

There could be several explanations for the eventual decline in measures of network popularity and centrality during secondary school. Contextual changes in education likely contribute. The relatively large size of most secondary classes, as compared to those in middle school, could make it increasingly difficult to maintain multiple friendships, for instance. Other explanations focus on the social maturation of youth as they proceed through the teen years. As

[2] Changes in missing data over time do not appear to account for the decline in network centrality, furthermore. The decrease in degree over time, for example, also is apparent in the number of names per respondent written down in the raw data, prior to coding of the names.

youth age, their friendships become closer and more involved (e.g., Berndt and Hawkins 1985; Bowker 2004), and so older youth may focus their social energies on smaller numbers of friends, with whom they are more intimate. Furthermore, as youth enter the later teen years and develop more independence from families, often beginning to drive themselves to social engagements, they gain additional control over their interactions. Such control might lead to increased time spent largely with an inner circle of friends.

Our results also demonstrate the key role of school transitions in shaping the friendship networks of youth. As hypothesized, all our measures of network centrality exhibit decreases following a school transition either from elementary to middle school or from middle to high school, while controlling for other factors. With one exception (betweeness centrality for the high school transition), the declines in centrality were statistically significant for the various types of centrality and for both levels of school transitions. Furthermore, the decrease in friendship popularity, or network indegree, associated with moves between levels of schooling did not dissipate over the subsequent years of high school. Teens who experienced a transition to high school during eighth to ninth grade, for example, continued to receive significantly fewer friendship nominations during their junior and senior years of high school, as compared to those who did not make the same transition. Note that these long-term effects on sociometric popularity would not be apparent in studies of shorter intervals.

A number of possible explanations arise for the negative effect of school transitions on friendship popularity and centrality. One concerns a lack of opportunity and availability for social interaction. Typically, upon entering high school, a student will have classes and school activities with many new students and have much less to no daily, school contact with former friends from middle and/or elementary school. This lack of regular contact likely leads to

students sending fewer friendship nominations to their old ties, and at the same time, new peers may not know each other well enough to consider each other friends. Other reasons concern the limitations of a sometimes large and intimidating, secondary school environment, combined with difficult academics, which may interfere with the time, energy, and motivation necessary to develop an extensive friendship network for a number of individuals. This trend of lowered centrality is not only evident in the year immediately following the transition to high school, but remains when students are in eleventh and twelfth grade, which suggests that there are long term consequences to these school, structural changes.

Our general findings reinforce several of the tenets of a life course perspective on the social development of youth. The dramatic pattern in our study regarding the evolution of friendship over time from middle school through high school, highlights the importance of gathering information from lengthy segments of the life course. In addition, according to this theory, life transitions can alter and change individuals' developmental paths in substantial ways, and here we see considerable evidence of such effects for an important life transition, that of changing levels of education. Our focus on the linked lives of young people's friendship networks also demonstrates the ways in which certain friendship ties, presumably those that are the most peripheral fade with time, as suggested by life course arguments (Wrzus et al. 2012). Such a perspective maintains, nevertheless, that the inner core of the linked life, network convoy tends to remain more stable.

Although there are a number of strengths to our investigation, there remain certain limitations. For example, our networks do not include data regarding friendships that occur either outside of grade or outside of school, and therefore our conclusions are limited to the effects of transitions on within grade friendships. While supplementary analyses suggest that estimates of

these other types of friendships do not alter our main conclusions, additional research is required to explore this issue more formally. Moreover, although our sample of schools is extensive, large, urban communities are underrepresented, and findings may differ in such environments.

We also do not have information regarding young people's satisfaction with their friendships. It remains possible that although friendship network popularity and centrality decline over time, the smaller numbers of friendships that remain are more rewarding to individuals than were the larger numbers of past friendships. As mentioned previously, as youth mature, they may learn to concentrate their social efforts on a particularly satisfying, select group of confidants. Nevertheless, the experience of decreasing network centrality over time likely leads at least some older teenagers to feel that they are becoming peripheral to their own social group, and such feelings could be quite stressful and deleterious. Additional research is needed to investigate the possible consequences for teens of the friendship trends documented in this project.

In conclusion, the friendship structure of young people often shifts considerably during the years from middle to high school, resulting in shrinking network centrality. Changing schools to middle or high school exacerbates the negative, over time ramifications for individual centrality, and these effects of school transitions can linger even until senior year. Our study calls attention to this noteworthy phenomenon in which the linked lives of adolescents appear to experience significant paring down during secondary school, and it suggests the need for further study.

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Figure 1. Normalized average centrality scores by grade scaled by the minimum and maximum of indegree [2.226, 4.043]

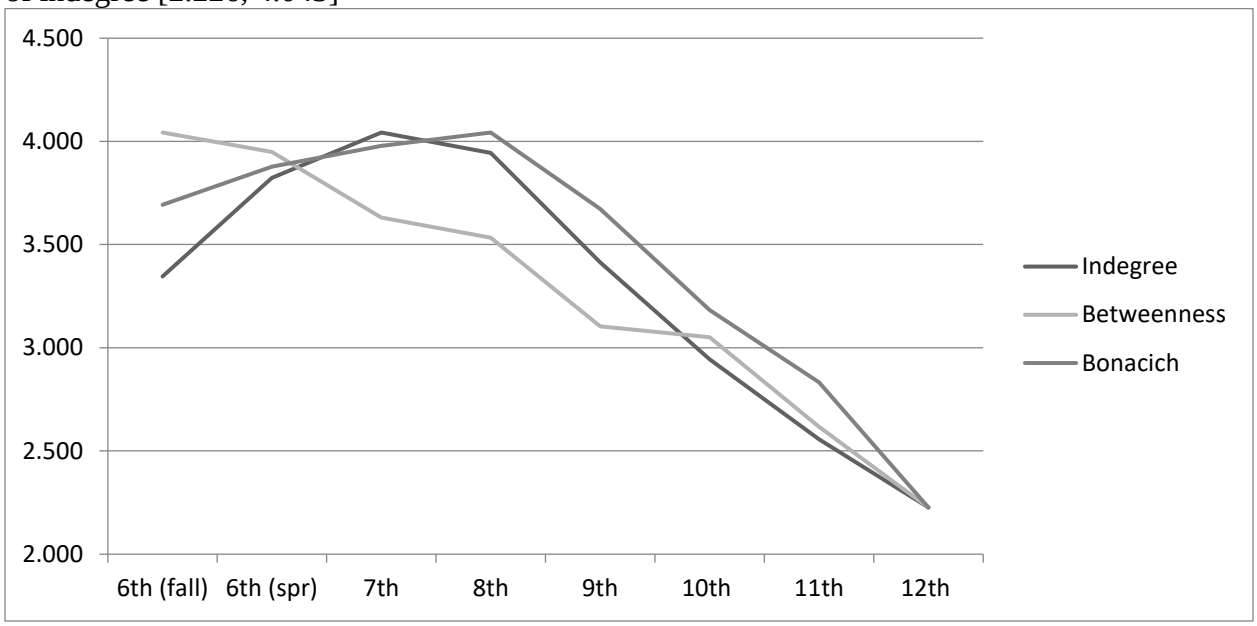
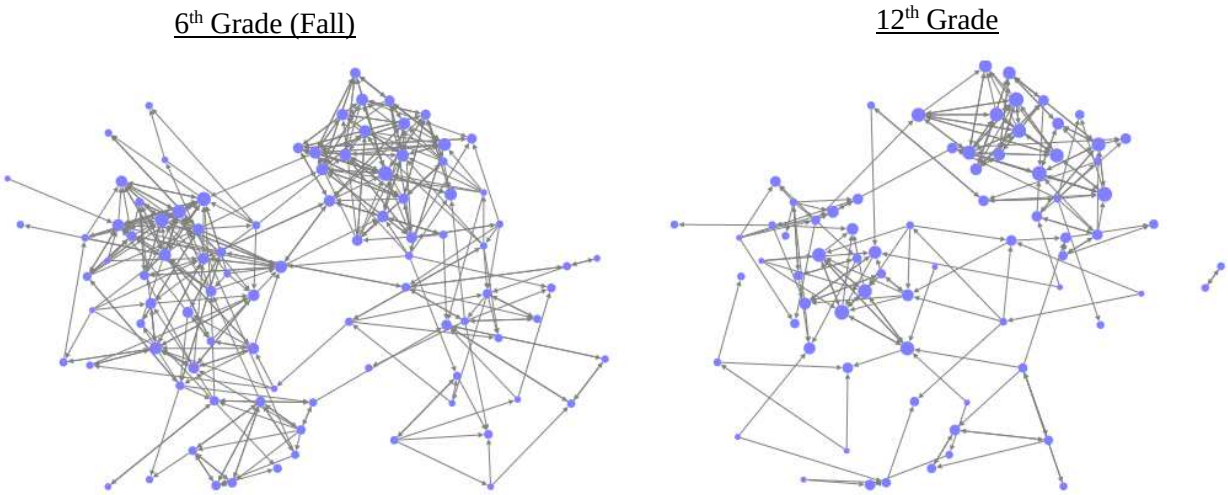


Figure 2. Friendship networks in a small school district during sixth and twelfth grade



Nodes are sized by indegree. Twelfth grade nodes have been locked in place so that each node is in the same exact location as it was in sixth grade. Isolates and missing nodes were removed from both graphs.

Table 1. Descriptive Statistics averaged over waves 1-8

	Mean	S.D.	Max.	Min.
Indegree	3.343	2.676	0	20
Bonacich Centrality*	0.763	0.589	0	4.555
Betweenness Centrality*	0.017	0.028	0	0.466
Transition after 6th Grade	0.353	-	0	1
Transition after 8th Grade	0.843	-	0	1
Transition after 9th Grade	0.078	-	0	1
Cohort 1	0.491	-	0	1
Iowa	0.507	-	0	1
Female	0.515	-	0	1
White	0.849	-	0	1
Free/Reduced Lunch	0.268	-	0	1
School Adjustment & Bonding	3.723	0.751	1	5
Lives with Both Bio. Parents	0.604	0.489	0	1
Grades	4.041	0.902	1	5
Delinquency	1.472	2.437	0	12

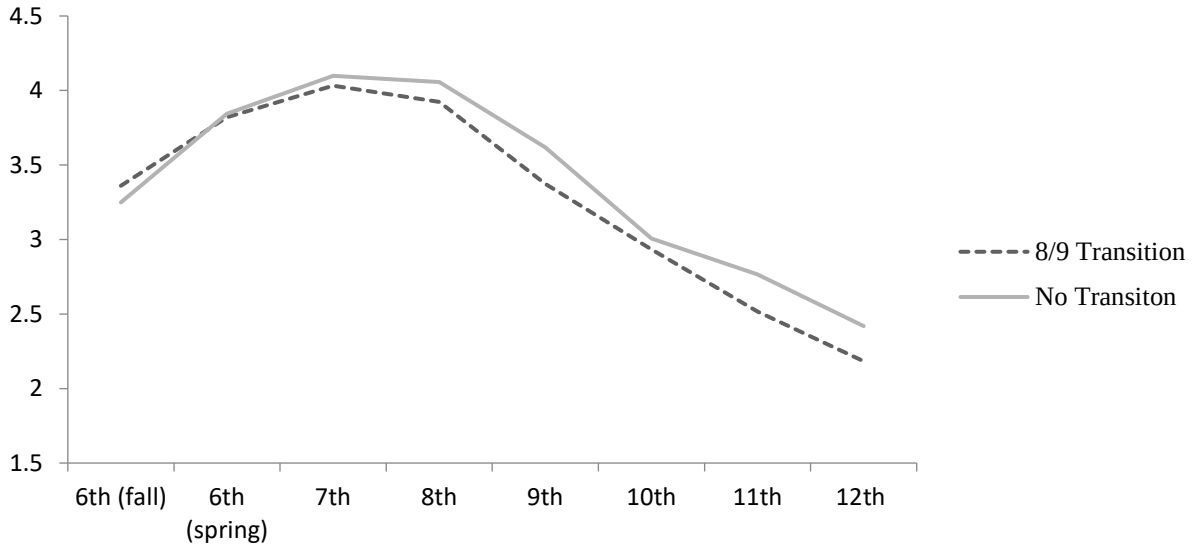
*Statistics are for the non-transformed centrality measures

Table 2. Average measures of individual centrality by wave

	Indegree		Bonacich*		Betweenness*	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
6th (Fall)	3.355	2.635	0.785	0.574	0.023	0.035
6th (Spring)	3.824	2.842	0.805	0.563	0.022	0.032
7th	4.041	2.962	0.814	0.554	0.020	0.027
8th	3.931	2.781	0.821	0.547	0.019	0.026
9th	3.402	2.584	0.781	0.582	0.016	0.024
10th	2.934	2.392	0.733	0.613	0.015	0.026
11th	2.562	2.236	0.697	0.626	0.012	0.023
12th	2.224	2.052	0.636	0.637	0.010	0.021

*Statistics are for the non-transformed centrality measures

Figure 3. Average indegree for students experiencing a transition from eighth grade to ninth grade compared to those who did not



Note: Differences in average indegree were statistically significant for 9th, 11th, and 12th grade, as confirmed by a two-tailed *t*-test ($p < 0.05$). Differences for all other grades were not statistically significant.

Table 3. Multi-Level Regression Model Predicting Indegree for 7th Grade Students (n = 9,473)

	Model 1		Model 2	
Transition After 7th	-0.242	+	-0.287	+
	(0.138)		(0.151)	
Girl	0.849	***	0.818	***
	(0.060)		(0.073)	
Girl x Transition After 7th			0.089	
			(0.123)	
White	0.342	***	0.343	***
	(0.087)		(0.087)	
Free/Reduced Lunch	-0.941	***	-0.940	***
	(0.069)		(0.069)	
School Bonding	-0.037		-0.037	
	(0.046)		(0.046)	
Lives with Both Bio. Parents	0.361	***	0.361	***
	(0.064)		(0.064)	
Grades	0.400	***	0.397	***
	(0.037)		(0.037)	
Delinquency	0.0567	***	0.057	***
	(0.015)		(0.015)	
Number of Students	-0.001	+	-0.001	+
	(0.000)		(0.000)	
Iowa	0.020		0.021	
	(0.132)		(0.132)	
Intercept	2.237	***	2.250	***
	(0.280)		(0.281)	
Variance Components				
Intercept 1	0.036	**	0.189	**
Level 1	7.935	***	7.935	***
Intercept 2	0.066	***	0.257	***

Standard errors for b-coefficients are in parentheticals.
+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4. Multi-Level Regression Model Predicting Indegree for 9th Grade Students (n = 9,633)

	Model 1		Model 2	
Transition After 8th	-0.275	*	-0.335	*
	(0.124)		(0.141)	
Girl	0.729	***	0.629	***
	(0.051)		(0.125)	
Girl x Transition After 8th			0.119	
			(0.136)	
White	0.414	***	0.412	***
	(0.073)		(0.073)	
Free/Reduced Lunch	-0.753	***	-0.754	***
	(0.063)		(0.063)	
School Bonding	0.066		0.066	
	(0.042)		(0.042)	
Lives with Both Bio. Parents	0.383	***	0.382	***
	(0.055)		(0.055)	
Grades	0.335	***	0.335	***
	(0.032)		(0.032)	
Delinquency	-0.753	***	-0.754	***
	(0.063)		(0.063)	
Number of Students	-0.001	***	-0.001	***
	(0.000)		(0.000)	
Iowa	-0.070		-0.071	
	(0.089)		(0.089)	
Intercept	1.678		1.729	***
	(0.231)		(0.125)	
Variance Components				
Intercept 1	0.209	***	0.044	***
Level 1	2.470	***	6.100	***
Intercept 2	0.023		0.001	

Standard errors for b-coefficients are in parentheticals.
+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$