NEIGHBORHOOD AND FAMILY EFFECTS ON TRAJECTORIES OF PHYSICAL AND SOCIAL AGGRESSION DURING ADOLESCENCE: THREE STUDIES USING MULTILEVEL GROWTH CURVE MODELING

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ABSTRACT

Katherine Joan Karriker-Jaffe – Neighborhood and family effects on trajectories of physical and social aggression during adolescence: Three studies using multilevel growth curve modeling

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This dissertation employed multilevel growth curve models to examine the development of physical and social aggression during adolescence and assessed neighborhood- and family-level predictors of the developmental trajectories. The first study showed that perpetration of physical and social aggression followed curvilinear trajectories between ages 11 and 18, with increases in each type of aggression followed by declines. Girls had significantly lower initial levels of physical aggression than boys. Sex did not impact rates of change of physical aggression, and boys consistently perpetrated more physical aggression than girls did. There were no sex differences in the initial levels or rates of change of social aggression. The second study found that the effects of neighborhood socioeconomic disadvantage and social disorganization on aggression trajectories were best described by direct effects models, rather than the hypothesized moderation models. For girls, neighborhood socioeconomic disadvantage was positively associated with initial levels of physical aggression. There were no significant main effects of the neighborhood variables on social aggression for girls, and for boys, there were no significant main effects of the neighborhood variables for either type of aggression. There was evidence suggesting confounding of the effects of disadvantage and disorganization when predicting physical

aggression. The third study revealed that family factors did not moderate the relationship between neighborhood risk and the aggression trajectories as hypothesized. For boys, more family conflict and less parental control were associated with higher initial levels of physical aggression, and more family conflict, less parent-child bonding and less parental control were associated with higher initial levels of social aggression. For girls, more neighborhood socioeconomic disadvantage, more family conflict, less parent-child bonding and less parental control were associated with higher initial levels of physical aggression, and more family conflict and less parent-child bonding were associated with higher initial levels of social aggression. Family conflict also influenced the linear slopes of the girls' physical aggression trajectories and the linear slopes of the social aggression trajectories for both boys and girls. All significant predictors impacted initial levels of aggression, which suggests that early prevention programs are needed to reduce perpetration of aggression during adolescence.

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OVERVIEW

The three studies in this dissertation examined the development of aggression during adolescence and assessed factors that influence that development. The first study described physical and social aggression trajectories for boys and girls between ages 11 and 18. The subsequent studies investigated how neighborhood and family factors influence those trajectories by applying principles from social ecological models of health behavior (Sallis & Owen, 1997; Stokols, 1996). The second study was further informed by theories of social exclusion and relative disadvantage (Jencks & Mayer, 1990; Kramer, 2000), as well as collective socialization models (Sampson, Morenoff, & Gannon-Rowley, 2002; Wilcox, 2003) and social control and social learning theories (Baranowski, Perry, & Parcel, 2002; Kramer, 2000; Mazur, 1990) applied at the neighborhood level. I examined neighborhood-level moderation effects between physical and social conditions (Stokols, 1996), by establishing whether the effect of neighborhood socioeconomic disadvantage on aggression trajectories was moderated by neighborhood social disorganization. The third study explored the influence of multiple contexts of adolescent development (Bronfenbrenner, 1979; Cook, 2003), by examining cross-level moderation effects between neighborhood and family factors as related to aggression trajectories. I applied social control (Hirschi, 1969) and social learning theories (Baranowski et al., 2002; Mazur, 1990) to the family context and drew upon models of effective parenting (Baumrind, 1991; Darling & Steinberg, 1993) to complement the neighborhood-level theories.

Each of the studies used multilevel growth curve models (Raudenbush, 2001) to describe the aggression trajectories and to examine the impact of risk and protective factors on the trajectories during adolescence. These models provide information on initial levels, rates of

change, and peak ages of involvement in aggression, with high intercepts, fast rates of change and late peak ages of involvement in aggression suggesting problem behavior (Moffitt, 1993; Nagin, 1999; Nagin & Tremblay, 2001). Because aggression involves many distinct behaviors (Cairns, Cairns, Neckerman, Ferguson, & Gariépy, 1989), I separated physically and socially aggressive acts to ascertain whether the developmental trajectories, and the effects of neighborhood and family risk and protective factors on those trajectories, were similar for the distinct aggression outcomes.

The first study examined the development of physical and social aggression between ages 11 and 18 and compared those trajectories for adolescent males and females. The average trajectories for both physical and social aggression were expected to be curvilinear, with a positive linear slope and a negative quadratic slope, and the average trajectory for social aggression was expected to show a higher initial level and an earlier peak age than the average trajectory for physical aggression. Several sex differences were hypothesized. Specifically, adolescent males were expected to show higher initial levels of physical aggression than adolescent females, but adolescent females were expected to show higher initial levels of social aggression than males. Additionally, adolescent females were expected to show an earlier peak age of involvement in both physical and social aggression than males.

Although neighborhood characteristics have been found to be associated with aggressive behavior (Ingoldsby & Shaw, 2002; Jencks & Mayer, 1990; Leventhal & Brooks-Gunn, 2000; Sampson, Morenoff, & Raudenbush, 2005; Sampson, Raudenbush, & Earls, 1997), there has been little research on the influence of neighborhoods on youth aggression trajectories, particularly in nonmetropolitan areas. The second study determined whether neighborhood socioeconomic disadvantage and neighborhood social disorganization (indicated by neighborhood social bonding, social control and crime) interact or have direct effects on initial levels and rates of change of physical and social aggression. The interaction between

neighborhood socioeconomic disadvantage and social disorganization was hypothesized to affect the intercept, rates of change and peak age of involvement in aggression. Specifically, neighborhood social disorganization was expected to amplify the negative effects of neighborhood socioeconomic disadvantage, such that, the effect of a given level of disadvantage on the trajectories of physical and social aggression would be more profound as the level of social disorganization increased. The highest initial levels of aggression, fastest increases and latest peak ages of involvement are expected in those neighborhoods that are both socioeconomically disadvantaged and socially disorganized.

Some family factors may exacerbate the influence of neighborhood risk on youth (Howell & Hawkins, 1998), while protective behaviors by parents may serve as buffers between an adverse neighborhood environment and their children (Fitzpatrick & LaGory, 2000; Leventhal & Brooks-Gunn, 2000). Thus, the third study tested whether family characteristics (family conflict, parent-child bonding and parental control) moderated neighborhood influences on initial levels of and rates of change in physical and social aggression. High levels of family conflict were expected to exacerbate the negative influence of a given level of neighborhood socioeconomic disadvantage or social disorganization on youth development, while high levels of parent-child bonding and parental control were hypothesized to buffer the influence of negative neighborhood environments on the trajectories. The interactions were expected to affect the intercept, rates of change and peak ages of involvement in physical and social aggression, with higher intercepts, faster rates of change and later peak ages expected for youth living in high-risk neighborhoods (high socioeconomic disadvantage, high social disorganization) who also have high-risk family environments (high family conflict, low parent-child bonding, low parental control).

The data for this dissertation come from the Context of Adolescent Substance Use Study, a longitudinal study designed to investigate contextual influences on adolescent substance abuse and aggression, with a focus on peer networks, family characteristics and

neighborhood factors (Ennett et al., 2006). The study consisted of three components: (1) five waves of in-school surveys of adolescents from the public schools in three rural, nonmetropolitan counties in North Carolina; (2) telephone interviews with a randomly sampled cohort of parents; and (3) linking U.S. Census data with geocoded addresses. This dissertation included youth-report data on aggression and family characteristics, as well as parent-report data on the neighborhood context and U.S. Census data linked to block group geocodes.

PAPER 1: SEX DIFFERENCES IN PHYSICAL AND SOCIAL AGGRESSION TRAJECTORIES DURING ADOLESCENCE

Abstract

Purpose: To examine trajectories of physical and social aggression during adolescence and to describe sex differences in the trajectories.

Methods: Five waves of data on youth aggression were collected over 2.5 years through in-school surveys. The sample (N=5151) was 50.0% female, 52.1% white and 38.2% African-American. The average age was 13.1 years at Wave 1. Missing data were imputed using multiple imputation procedures. The average trajectories were described using multilevel growth curve models.

Results: Perpetration of physical and social aggression followed curvilinear trajectories from ages 11 to 18, with increases in each type of aggression followed by subsequent declines. The peak age was 14.9 for physical aggression and 13.8 for social aggression. Girls had significantly lower initial levels of physical aggression than boys at age 11. Boys consistently perpetrated more physical aggression than girls did, although the trajectories were parallel. There was no sex difference in the initial levels of social aggression. Girls and boys perpetrated the same amount of social aggression at all ages studied.

Conclusions: Boys and girls followed similar behavioral trajectories during adolescence for both physical and social aggression. Boys perpetrated as much social aggression as girls during adolescence, given the levels of involvement in both types of aggression, practitioners should include both physical and social aggression in prevention programs for youth.

Keywords: adolescent behavior, aggression, latent growth curve, multilevel models

Introduction

Youth aggression has been targeted for reduction by domestic (U.S. Department of Health and Human Services, 2000) and global (World Health Organization, 2002) initiatives. Longitudinal studies of the developmental trajectories of aggression can illuminate changes in perpetration patterns over time to inform prevention programming, but trajectories of different types of aggression and sex differences in the development of aggression have not been adequately studied, particularly in nonmetropolitan areas. This study examines trajectories of both physical and social aggression and describes how they differ for males and females using data from a predominantly rural area in the southeastern United States.

Aggression takes many forms, ranging from social and verbal aggression to physical aggression and more serious kinds of violence. Physical aggression includes behaviors that threaten or cause physical harm to other people, such as threats of bodily harm, physical fighting and violent crimes such as robbery, rape and homicide (Loeber & Hay, 1997). Social aggression encompasses various forms of non-physical aggression, such as indirect and relational aggression, which are focused on damaging social relationships rather than inflicting or threatening physical harm (Archer & Coyne, 2005). Socially aggressive behaviors include gossiping (Xie, Swift, Cairns, & Cairns, 2002), excluding or alienating someone socially (Xie, Swift et al., 2002), and trying or threatening to damage someone's social standing within a group (Crick & Grotpeter, 1995). Physical and social aggression have different relationships with risk factors and psychosocial variables (Crick & Grotpeter, 1995; Xie, Swift et al., 2002) and have different consequences for perpetrators and victims (Lagerspetz, Björkqvist, & Peltonen, 1988). Both of these types of aggression are common among youth in nonmetropolitan areas (Farrell, Kung, White, & Valois, 2000). Since social aggression perpetrated during adolescence has received less attention than physical

aggression from researchers and public health practitioners, this study examines the development of physical and social aggression during adolescence using multilevel growth curve models.

Advances in statistical modeling procedures, such as multilevel and random effects modeling, have made it possible to examine adolescent development by describing patterns, or trajectories, of behavior over several months or years using repeated measures of an outcome variable to describe behavior change (Raudenbush, 2001). With few exceptions, longitudinal trajectories of physical aggression (Aber, Brown, & Jones, 2003; Farrell, Sullivan, Esposito, Meyer, & Valois, 2005) and violence (Sampson et al., 2005) exhibit a curvilinear pattern that shows an increase in activity during early adolescence that peaks late in adolescence and then declines. Curvilinear trajectories have been shown for similar outcomes such as delinquency as well (Farrell et al., 2005; Windle, 2000). Age-offending curves, which use aggregate data to depict the prevalence or age of onset of aggressive or antisocial behaviors, also suggest curvilinear trends during adolescence and young adulthood (Benson, 2002; Elliott, 1994; Fergusson & Horwood, 2002; Loeber & Hay, 1997; Tolan, Gorman-Smith, & Loeber, 2000). For example, the Pittsburgh Youth Study showed curvilinear trends in aggression among boys that peaked between 15 and 16 years of age and then started to decline (Loeber & Hay, 1997). In contrast, one study of Dutch adolescents depicted a negative linear trajectory of parent-reported aggression that declined from ages 4 to 25 (Bongers, Koot, van der Ende, & Verhulst, 2003).

Research based on age-offending curves suggests that the developmental trajectories may differ for physical and social aggression (Loeber & Hay, 1997; Tolan et al., 2000). Generally, aggressive behaviors progress from less to more severe over the course of adolescent development (Loeber & Hay, 1997; Tolan et al., 2000). One study of urban, high-risk, African-American and Latino boys noted an earlier age of onset, higher prevalence rates and an earlier peak age of involvement for socially aggressive behaviors (such as teasing or

being mean to others) when compared to physically aggressive behaviors (such as physical fighting or violent crimes) (Tolan et al., 2000). Additional research suggests that social aggression may increase between the ages of 8 and 14 years of age (Connor, 2002), or it may peak in late childhood or preadolescence (Archer & Coyne, 2005), which would be earlier than the peak age of involvement typically observed for physical aggression. In contrast, some studies have found that social aggression develops later in adolescence, as social skills and awareness of interpersonal relationships become more advanced (Archer & Coyne, 2005; Cairns et al., 1989; Xie, Swift et al., 2002). However, most research on social aggression has been cross-sectional (Conway, 2005), and no studies have described developmental trajectories of social aggression during adolescence or compared trajectories of physical and social aggression. Thus, the first aim of this study is to describe the trajectories for physical and social aggression. The specific hypotheses are as follows:

Hypothesis 1: The average trajectories for both physical and social aggression will be curvilinear, with a positive linear slope and a negative quadratic slope.

Hypothesis 2: The average trajectory for social aggression will show a higher initial level and an earlier peak age than the average trajectory for physical aggression.

Curvilinear patterns of physical aggression and violence have been found in diverse samples of adolescents, and they appear to be similar for both males and females in trajectory studies (Farrell et al., 2005; Sampson et al., 2005) and based on sex-stratified age-offending curves (Elliott, 1994; Fergusson & Horwood, 2002; Loeber & Hay, 1997). However, males typically have higher rates of involvement in physical aggression and violence than females (Aber et al., 2003; Blitstein, Murray, Lytle, Birnbaum, & Perry, 2005; Blum et al., 2000; Bongers et al., 2003; Elliott, 1994; Farrell et al., 2000; Farrell et al., 2005; Fergusson & Horwood, 2002; Griffin, Botvin, Scheier, Diaz, & Miller, 2000; Heimer & DeCoster, 1999; Loeber & Hay, 1997; Sampson et al., 2005; Xie, Cairns, & Cairns, 2002). In the U.S., estimates of lifetime prevalence of at least one serious violent offense by age

seventeen are between 30-40% for young men, as compared to 16-32% for young women (U.S. Department of Health and Human Services, 2001). Similarly, data from national surveys has revealed that male high school students are more likely to indicate that they had been in a physical fight in the past year than females, and males are more likely than females to take weapons to school (U.S. Department of Health and Human Services, 2000).

Silverthorn and Frick (1999) hypothesize that antisocial behaviors among girls are delayed when compared to boys and that few antisocial behaviors begin prior to adolescence for girls. In general, females exhibit a later age of onset than males for most aggressive behaviors (Connor, 2002; Fergusson & Horwood, 2002; Loeber & Hay, 1997). Sex differences in aggression also become more extreme throughout puberty, as males continue involvement in aggression for a longer period of time and females' aggressive behaviors begin to decline at younger ages than males' (Fergusson & Horwood, 2002; Loeber & Hay, 1997). In fact, longitudinal studies have determined that young women have rates of serious violence that are just one-quarter those of young men by age 17 (U.S. Department of Health and Human Services, 2001) and that the age-crime curve for girls may peak as early as age 14 (Molnar, Browne, Cerdá, & Buka, 2005). These data suggest that boys would have higher initial levels and later peak ages of involvement in physical aggression during adolescence than girls.

In contrast, many studies suggest that social aggression is more common among girls than boys (Archer & Coyne, 2005; Connor, 2002; Crick, 1997; Crick & Grotpeter, 1995; Xie, Swift et al., 2002). However, one study found few sex differences in social aggression in a sample of rural sixth graders in the southeastern U.S. (Farrell et al., 2000). Since no studies have described the trajectories of social aggression during adolescence for either males or females, there is little evidence to suggest specific differences in boys' and girls' trajectories of social aggression during adolescence. To better understand sex differences in physical and social aggression perpetration during adolescence, the second aim of this study is to

determine whether sex predicts initial levels and trajectories of physical and social aggression between ages 11 and 18. The specific hypotheses are as follows:

Hypothesis 3: The average physical and social aggression trajectories for both males and females will be curvilinear, with a positive linear slope and a negative quadratic slope.

Hypothesis 4: Adolescent males will show higher initial levels of physical aggression than adolescent females, but adolescent females will show higher initial levels of social aggression than males.

Hypothesis 5: Adolescent females will show an earlier peak age of involvement in both physical and social aggression than males.

Methods

Study Design

The data for this study come from the longitudinal, school-based Context of Adolescent Substance Use Study, which was designed to investigate contextual influences on adolescent substance abuse and aggression, with a focus on peer networks, family characteristics and neighborhood factors (Ennett et al., 2006). The study included adolescents from the public schools in three predominantly rural counties in North Carolina. These counties are eligible for targeted federal funds for health services due to their rural location and low population density and are classified as nonmetropolitan areas with access to an interstate highway (Ricketts, Johnson-Webb, & Randolph, 1999). As shown in Table 1, these counties also have greater proportions of African-Americans than does the general United States population, and the median household income and median housing value are lower than the national medians (U.S. Census Bureau, 2002).

Table 1. Comparison of demographic data for United States and study counties

	United States	Study Counties
Demographic composition (%)		
Black/African-American	12.2	27.7
White	75.1	68.8
Other race/ethnicity	12.7	3.5
Hispanic/Latino [a]	12.5	3.5
Living in rural area [b] (%)	21.0	59.9
Lived in same house for at least 5 years (%)	54.1	58.3
Median housing value in 1999	$111,800	$89,400
Median household income in 1999	$41,994	$36,567
For blacks/African-Americans	$29,423	$24,911
For whites	$44,687	$41,744
Income in 1999 below poverty level (%)	12.4	14.1
For blacks/African-Americans	24.9	26.9
For whites	9.1	8.5
People over age 16 who are unemployed (%)	5.7	6.1
For blacks/African-Americans	11.6	11.0
For whites	4.6	4.4
People over age 25 with less than high school education (%)	19.6	23.0
For blacks/African-Americans	27.7	36.5
For whites	16.4	17.8
People over age 25 who attended at least some college (%)	51.8	46.1
For blacks/African-Americans	42.5	28.9
For whites	54.1	52.3

Note. Data from U.S. Census (2002). [a] Hispanic/Latino not mutually exclusive with other race/ethnicity categories. [b] Rural is defined as a place of less than 2,500 persons. All urban residents in the study counties lived in urban clusters of less than 50,000 persons.

The Context of Adolescent Substance Use Study consists of three components: (1) in-school surveys with adolescents (county-wide census), (2) telephone interviews with a randomly sampled cohort of parents, and (3) linking U.S. Census data with geocoded addresses. Between 2002 and 2004, eligible students completed fives waves of surveys in the schools, and parents participated in three sets of telephone interviews. Addresses from students who completed questionnaires and from parents who completed interviews were geocoded and linked to U.S. Census block groups at each wave. Response rates for all three study components are included in Table 2. The Public Health Institutional Review Board at The University of North Carolina at Chapel Hill approved all study protocols.

Table 2. Study design and response rates

	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5
Students					
Grades	6th, 7th, 8th	7th, 8th, 9th	7th, 8th, 9th	8th, 9th, 10th	8th, 9th, 10th
Sample size	5,220	5,060	5,059	5,017	4,676
Response rate	88.4%	81.3%	80.9%	79.1%	76.0%
Addresses geocoded [a]	99.6%	99.5%	99.0%	53.8%	55.0%
Parents					
Sample size	1,663	---	1,372	---	1,194
Response rate	79.8%	---	82.5%	---	71.8%
Addresses geocoded	100.0%	---	98.3%	---	95.3%

[a] One of the three study counties did not provide addresses for the students after Wave 3.

This paper includes data from all five waves of the in-school surveys, and the analyses account for clustering of students resulting from the school-based data collection procedures. Because schools draw their students from different neighborhoods, I used the

students' neighborhoods (defined by the Wave 1 Census block group) as the unit of clustering. Although neighborhoods are imperfectly clustered within schools, other researchers have found similar results when comparing data on adolescent outcomes clustered by school with data clustered by neighborhood (Cook, Herman, Phillips, & Settersten, 2002). Additionally, studies have found that U.S. census block groups adequately delineate social and structural determinants of health and health behavior (Cook, Shagle, & Degirmencioglu, 1997; Krieger et al., 2002).

In-School Surveys

As shown in Table 2, five waves of data were collected from adolescents in schools every 6 months between spring 2002 and spring 2004, beginning when the students were in sixth, seventh or eighth grade and ending when they were in eighth, ninth or tenth grade. At each wave, all adolescents in the public schools in the three study counties were eligible for participation (approximately 6,100 students) except those who could not complete the questionnaire in English (approximately 15 students) and those who were in special education programs (approximately 300 students). At each wave, new students who met the inclusion criteria entered the study.

Parents were notified about the study and had the opportunity to refuse consent for their child's participation at the beginning of each academic year and whenever a new student became eligible for the study. At each wave, trained research assistants administered questionnaires on at least two different occasions at each school to allow those students who had been absent on the primary day of data collection to participate in the study on the make-up day. To maintain confidentiality, all teachers remained at their desks while the students completed their questionnaires, and the students placed their questionnaires in envelopes before returning them to the data collectors.

Address Geocoding

Student addresses received from the schools were sent to a commercial geocoding firm to be matched with U.S. Census tracts and block groups. The geocode matches varied in precision from the most precise street matches to the least precise 5-digit ZIP centroid matches. Addresses that were not matched at the street level were cleaned and checked using the U.S. Postal Service website (U.S. Postal Service, n.d.) and a general address mapping website (MapQuest, n.d.), and then a second attempt was made to geocode them using either ArcGIS software (ESRI, 2005) or the U.S. Census American FactFinder website (U.S. Census Bureau, n.d.). The final geocode for each address was assigned based on the results of all geocoding attempts such that street matches were preferred over ZIP centroid matches. The geocodes included all tracts and block groups in the three study counties (n=113), as well as some additional tracts and block groups from surrounding areas (n=40). The match rates for all waves are included in Table 2.

As recommended by Krieger and colleagues (2001), an accuracy study was conducted to evaluate the geocodes returned by the commercial firm and those generated using the ArcGIS software. The accuracy study consisted of a random sample of street matches, stratified by county, generated using a SAS survey selection program (SAS Institute, 2003). The sample of addresses was re-geocoded using the American FactFinder website, which represented the gold standard (Krieger et al., 2001). Overall, 90.4% of the addresses checked for accuracy matched the gold standard perfectly and an additional 4.3% matched at the tract level but not at the block group level.

Analysis Sample

The analysis sample (N=5151) includes those adolescents who completed a Wave 1 questionnaire, except for those who were younger than 11 or older than 16.5 (N=26) at Wave 1, those who did not give their birth date or sex on any of the five questionnaires (N=8), and

those without a Wave 1 block group geocode (N=35). The age restriction was imposed to limit the number of students who were out of the typical age range for their grade, and the block group was necessary to account for similarities among students from the same neighborhood.

The students completed the Wave 1 survey at thirteen different schools drawn from 153 block groups. Overall response rates for the analysis sample ranged from 86.4% at Wave 2 to 79.4% at Wave 5. Of the students in the sample, 55.8% participated in the study at all five waves, 15.5% participated in four waves, 15.1% in three waves, 5.4% at just two waves and 8.2% only at Wave 1. Procedures for imputing missing data are described below.

At Wave 1, the sample was approximately equally divided among the sixth (35.5%), seventh (33.1%) and eighth (31.4%) grades, and the majority of students (95.6%) were between the ages of 11 and 14 (M=13.1 years). Half (50.0%) of the sample was female, and 51.2% of the students were white, 38.2% were black or African-American, 3.8% were Hispanic or Latino and 5.9% were another race or ethnicity (including multiracial or mixed race, American Indian or Native American, Asian or Pacific Islander, or "other"). Most students (80.0%) lived with two parents (either a mother and father, mother and stepfather, or stepmother and father). The highest level of education reported for either parent was less than a high school diploma for 6.2% of students, 20.7% had a parent who had graduated from high school, and 73.1% had a parent with at least some college, community college or technical school training. At Wave 1, 48.5% of students had perpetrated physical aggression (45.1% of sixth graders, 48.1% of seventh graders, and 53.0% of eighth graders) and 69.5% had perpetrated social aggression (64.3% of sixth graders, 69.3% of seventh graders, and 75.6% of eighth graders).

Measures

Although there are many metrics for the passage of time in longitudinal studies (Curran & Willoughby, 2003), to be consistent with prior research on youth aggression, this study models both outcomes as a function of chronological age. To reduce errors associated with birth dates reported incorrectly by younger respondents, age was calculated based on the modal birth date (modal month, modal day and modal year) for all available waves of data. Age was centered by subtracting 11 (the youngest age in the sample at Wave 1) so that the intercepts could be interpreted easily.

Physical and social aggression were measured at all five waves. The physical aggression scale (Farrell et al., 2000) assessed how many times in the past three months the respondent had been in a fight in which someone was hit, hit or slapped another kid, threatened to hurt a teacher and threatened someone with a weapon. Social aggression included the following items: excluded another student from his or her group of friends, spread a false rumor about someone, picked on someone, and started a fight between other people (Farrell et al., 2000). The responses for each item were *none* (0), *1-2 times* (1), *3-5 times* (2), *6-9 times* (3), or *10 or more times* (4). The responses were summed to form a continuous total score for each type of aggression, such that higher scores indicated higher levels of aggression. To adjust for skewness, the total aggression scores were log-transformed after adding a constant. The Cronbach's alpha ranged from .68 for both the physical aggression scale (M=1.27, SD=2.03) and the social aggression scale (M=2.09, SD=2.48) at Wave 1 to .86 for the physical aggression scale (M=1.36, SD=2.94) and .83 for the social aggression scale (M=2.05, SD=3.20) at Wave 5.

I determined values for the demographic variables based on all available data across the five waves of questionnaires. Sex was coded with female as the reference category (0). The analyses control for other demographic characteristics, including the adolescent's race or ethnicity, parent education, and family structure. The student's self-reported race or

ethnicity was based on the modal response across all waves, and it was represented by three mutually-exclusive dummy variables (black or African-American, Hispanic or Latino, or other race/ethnicity) with white as the reference category (0). Parent education was measured by the highest level of education attained by either parent, and it included *less than a high school education* (0), *graduated from high school* (1), *some college, community college or technical school* (2), *graduated from community college or technical school* (3), *graduated from college* (4), and *graduate or professional school after college* (5). Family structure was a dichotomous variable indicating residence in a single-parent household at any time during the study (1) compared to continuous residence in a two-parent household (0).

Missing Data

Missing values are common in longitudinal research with adolescents (Faden et al., 2004). To minimize the possible impact of attrition bias in longitudinal studies, missing values were replaced using multiple imputation procedures (Rubin, 1987). First, I specified a missingness equation to guide the imputation. This equation included the dependent variables at all five waves, the independent variables, variables highly correlated with the outcomes from all five waves, variables containing special information about the sample and other variables thought to be associated with missingness (Allison, 2000; Horton & Lipsitz, 2001; Patrician, 2002).

All of the variables included in the imputation were either continuous or dichotomous (Allison, 2005), and I confirmed that the variables were not collinear using eigenanalysis (Belsley, Kuh, & Welsch, 1980) and by inspecting variance inflation factors (Neter, Wasserman, & Kutner, 1990). I used SAS PROC MI (SAS Institute, 2003) to impute the missing values based on the missingness equation using the Markov Chain Monte Carlo (MCMC) specification (Yuan, 2000). I bounded the imputed values to the valid ranges of the

data, and I allowed all imputed dichotomous variables to range between 0 and 1 rather than rounding the values, in accordance with the recommendations of Allison (2005).

The analysis results were combined across the ten imputed datasets using SAS PROC MIANALYZE (Horton & Lipsitz, 2001), which accounts for the uncertainty of the imputation process when calculating summary test statistics, parameter estimates and standard errors. All models had relative efficiencies greater than .95, which suggests that the number of imputations was sufficient to achieve stable estimates (Horton & Lipsitz, 2001).

Analysis Strategy

I used multilevel growth curves to model each outcome (physical and social aggression) from ages 11 to 18. All analyses used PROC MIXED in SAS version 9.1 on a SunOS 5.9 platform (SAS Institute, 2003) using a restricted maximum likelihood estimation process and the Kenward-Roger adjustment of the standard errors and degrees of freedom for more conservative tests of the fixed effects (Kenward & Roger, 1997).

Multilevel Models

Random effects models (including multilevel models and latent growth curve analyses) can be used to describe patterns or trajectories of behavior over time, as well as to assess predictors of those trajectories (Curran & Willoughby, 2003; Guo & Hipp, 2004; Raudenbush & Bryk, 2002). In the modeling process, within-person (level-1) models define a trajectory for each individual in the sample, and then between-person, individual-level (level-2) models provide the means and variance of the trajectories across the individuals in each cluster (Curran & Willoughby, 2003). Additional level-3 models provide information on the variability of trajectories between clusters. The multilevel equation can be specified as:

$$\mathbf{Y_{tij} = \pi_{oij} + \pi_{1ij}(AGE)_{tij} + \pi_{2ij}(AGE^2)_{tij} + e_{tij}} \qquad \text{i=1,...,5151; j=1,...,153} \qquad (1)$$

$$\mathbf{\pi_{pij} = \beta_{poj} + \sum_{q=1}^{Q_p} \beta_{pqj} X_{qij} + r_{pij}} \qquad \text{p=0, 1, 2} \qquad (2)$$

$$\mathbf{\beta_{pqj} = \gamma_{pqo} + u_{pqj}} \qquad \text{p=0, 1, 2; q=0, 1,...,}Q_p \qquad (3)$$

The level-1 model (1) denotes change over time within individuals. In this study, Y_{tij} represents the observed aggression score at age t for child i in neighborhood j, and it is a function of a quadratic curve plus random error (e_{tij}). Thus, π_{oij} is the total aggression score of child$_{ij}$ at age 11, π_{1ij} is the linear slope for aggression for child$_{ij}$, and π_{2ij} is the quadratic slope for child$_{ij}$.

The level-2 models (2) denote differences between individuals within clusters, and they are used to predict the parameters from the level-1 model. To test the study hypotheses, sex predicts the intercept (π_{oij}), linear slope (π_{1ij}) and quadratic slope (π_{2ij}) from the level-1 model. Based on preliminary analyses, I also allowed the control variables (race/ethnicity, parent education and family structure) to predict the level-1 intercept and linear slope. β_{poj} is the intercept for neighborhood j in modeling the child effect π_{pij}, where X_{qij} is one of the Q_p individual-level covariates characteristic of child i in neighborhood j. β_{pqj} represents the effect of X_{qij} on the pth growth parameter, and r_{pij} are the random effects for each child.

The level-3 model (3) accounts for clustering within neighborhoods by adding a random effect for each neighborhood (u_{ooj}) when predicting the intercept from the level-2 model (β_{ooj}). The level-2 linear and quadratic slopes are fixed between neighborhoods ($u_{1qj} = 0$ and $u_{2qj} = 0$).

The preliminary models included four random effects (neighborhood intercept, individual intercept, individual linear slope and individual quadratic slope), but not all of the random effects were estimable, which suggests that there were more random effects than the data could support given the limited number of time points per subject. All of the random

effects were estimable once the random individual quadratic slope was dropped from the model (i.e. at level 2, $r_{2ij} = 0$). Thus, I included three random effects in the models (neighborhood intercept, individual intercept and individual linear slope), and I allowed the level-2 random effects to correlate. At the individual level (level-2), the random effects indicate variability of individual trajectories (the within-person models). At the neighborhood level, the random effects indicate the level of variability across the different neighborhoods in the sample.

Analyses to Test Study Hypotheses

In accordance with the first aim of the study (to describe the trajectories of physical and social aggression), I used unconditional models to depict the observed aggression score at age t for child i in neighborhood j as a function of a quadratic curve plus random error for each cluster (u_{00j}), for each child within each cluster (r_{0ij} and r_{1ij}), and for each child over time (e_{tij}).

I used the unconditional models and a model including sex as a covariate to test the hypotheses about curvilinear trajectories. To test whether the aggression trajectories were curvilinear, I first assessed whether the trajectories were flat (if a joint F-test indicated that the linear slope and the quadratic slope were not significantly different from zero). Then, I evaluated whether there was a significant positive linear slope, and finally I confirmed there was a significant negative quadratic slope. Under a quadratic model, the peak age is obtained from the first derivative using a ratio of the regression coefficients ($-B_{age}/2B_{age\text{-}squared}$). A Taylor series approximation (the delta method) was used to obtain the standard error of the estimated peak age for physical and social aggression (Sen & Singer, 1993).

Because the MIANALYZE procedure does not include the covariance parameters from mixed models, I combined the covariance parameters for the unconditional models across

the ten imputed datasets using the formulas provided by Rubin and Schafer (1997). I also calculated the correlation between the random individual intercept and the random individual linear slope to describe how initial levels of aggression were related to change over time.

The second aim of the study was to determine whether sex predicts the initial levels and trajectories of physical and social aggression. For these analyses, I used conditional models that included sex, interactions of sex with age and age-squared, and the individual-level control variables (main effects and interactions with age) as predictors of the two types of aggression. The conditional models were simplified using backwards elimination to remove any product terms involving sex and age or age-squared that were not statistically significant. Nonsignificant interactions involving the control variables and age were not trimmed from the model.

Results

The unconditional models describing the basic physical and social aggression trajectories are presented in Table 3. In accordance with my hypotheses, the joint *F*-tests of the linear and quadratic slopes for physical aggression ($F(2, 81.38) = 31.86$, $p < .01$) and social aggression ($F(2, 169.12) = 56.83$, $p < .01$) and the direction of the coefficients (significant positive linear slopes and significant negative quadratic slopes) suggest that the trajectories for both physical and social aggression were curvilinear, with initial increases in aggression followed by declining values after age 14.9 for physical aggression and after age 13.8 for social aggression. As hypothesized, the initial levels of social aggression were higher than the initial levels of physical aggression among the students in the study, and social aggression peaked 12 months earlier than physical aggression. Figure 1 shows the trajectories for physical and social aggression. As shown in the top panel, there was some discrepancy between the predicted and observed values of aggression at the oldest ages included in the

study, perhaps due to the small numbers of participants in the sample who were older than 16.

Description of the random effects also comes from the unconditional models (see Table 3). For physical aggression, the variances of the three random effects were significant. The random neighborhood intercept indicates that there was significant variation between neighborhoods in the initial levels of physical aggression. The random individual intercept shows there was significant variation in the initial levels of physical aggression between individuals nested within neighborhoods, and the random individual slope indicates there was significant variation in the linear change over time between individuals nested within neighborhoods. There was a strong negative correlation between the random individual intercept and the random linear slope ($r = -0.56$), which suggests that those adolescents who had higher initial levels of physical aggression showed slower rates of linear change over time. In contrast, those who had lower initial levels of physical aggression increased more rapidly over time.

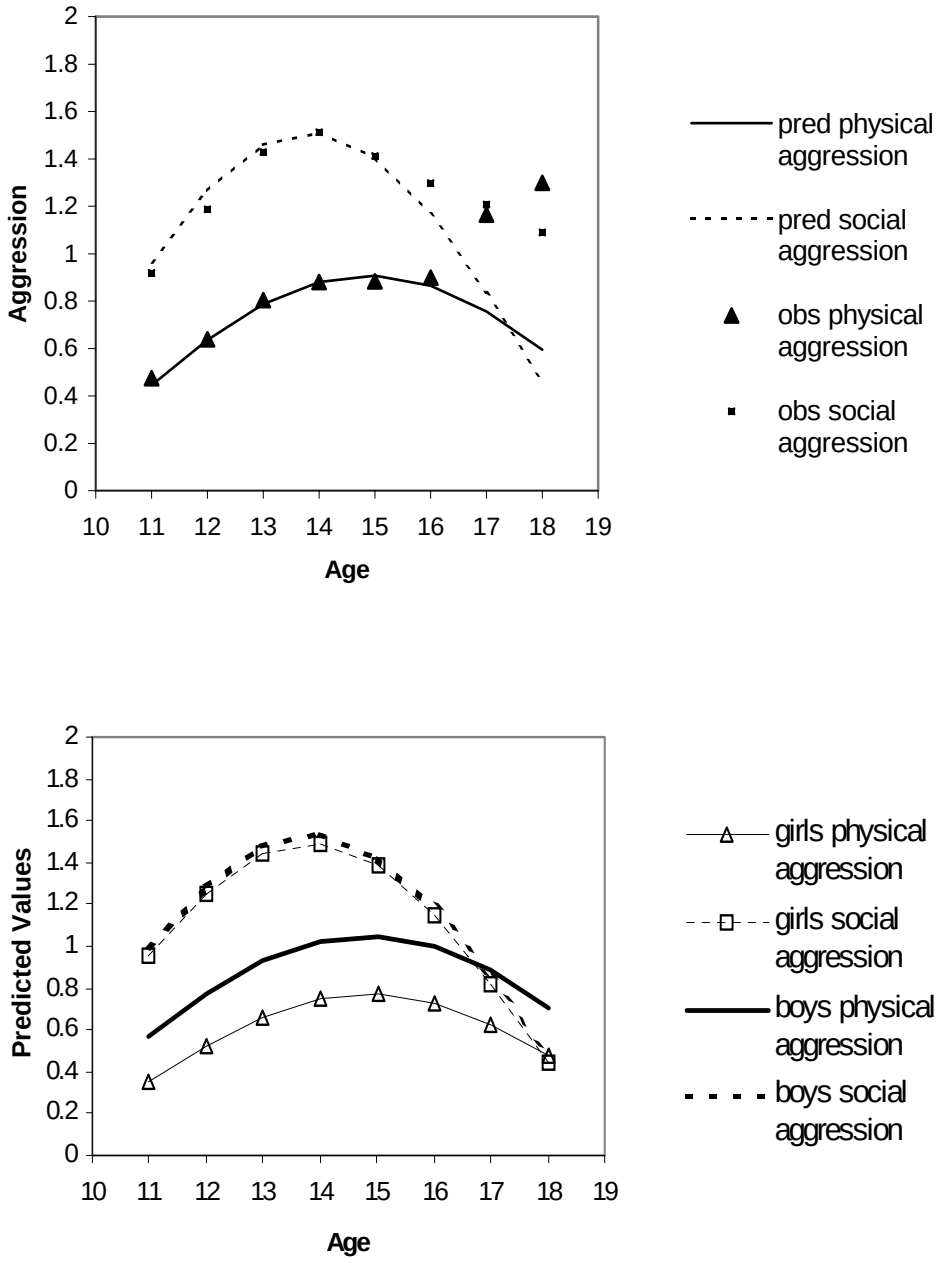
For social aggression, the variances of two of the random effects were significant. The random individual intercept and the random individual slope indicate that there was significant variation in both the initial levels and linear change in social aggression over time between individuals nested within neighborhoods. There was not a significant amount of variation between neighborhoods in the initial levels of social aggression. As with physical aggression, there was a strong negative correlation between the random individual intercept and the random linear slope ($r = -0.68$) for social aggression. Those adolescents who had higher initial levels of social aggression showed slower rates of linear change over time. In contrast, those who had lower initial levels of social aggression increased more rapidly over time.

Table 3. Unconditional and reduced conditional models of physical and social aggression from age 11 to age 18 (N=5151)

	Unconditional Models			
	Physical Aggression		Social Aggression	
	B	95% CI	B	95% CI
Fixed effects				
Intercept	0.37*	(0.31, 0.43)	0.67**	(0.62, 0.73)
Age	0.14**	(0.11, 0.18)	0.17**	(0.14, 0.21)
Age-squared	-0.02*	(-0.02, -0.01)	-0.03**	(-0.04, -0.02)
Random effects				
Individual intercept	0.26*	(0.21, 0.31)	0.42*	(0.35, 0.48)
Individual linear slope	0.02*	(0.01, 0.02)	0.03*	(0.02, 0.03)
Neighborhood intercept	0.01*	(0.01, 0.02)	0.002	(-0.001, 0.005)
Peak age (years)	14.88	(13.94, 15.83)	13.82	(13.33, 14.31)
	Reduced Conditional Models			
	Physical Aggression		Social Aggression	
Intercept	0.26**	(0.16, 0.35)	0.59**	(0.49, 0.70)
Age	0.12**	(0.08, 0.16)	0.16**	(0.12, 0.21)
Age-squared	-0.02**	(-0.02, -0.01)	-0.03**	(-0.04, -0.02)
Sex	0.14**	(0.12, 0.17)	0.01	(-0.01, 0.05)

Note. CI = confidence interval. All analyses controlled for race/ethnicity, parent education, and family structure. * $p < .05$. ** $p < .01$.

Figure 1. Trajectories of physical and social aggression from ages 11 to 18: Unconditional trajectories with observed means (top panel) and sex-specific conditional trajectories (bottom panel)



Note. Obs = observed values. Pred = predicted values.

Results from the reduced conditional models also are presented in Table 3. In accordance with my hypotheses, joint *F*-tests from conditional models assessing the effect of sex alone (not shown) for physical aggression ($F(2, 80.25) = 30.42$, $p < .01$) and social aggression ($F(2, 167.61) = 56.84$, $p < .01$) and the direction of the coefficients (both outcomes showed significant positive linear slopes and significant negative quadratic slopes) suggest that the trajectories for both physical and social aggression were curvilinear even when accounting for sex. There was partial support for my hypotheses about sex differences in the trajectories. There was a significant main effect for sex for physical aggression, but not for social aggression. This indicates that males had higher initial levels of physical aggression than females, but there was no significant difference in the levels of social aggression at age 11 between males and females. The final reduced model was a main effects model, and there were no significant interactions between sex and age-squared or age. Thus, the growth curves for males and females were the same shape, and there was no support for the hypothesis regarding sex differences in the peak age of involvement in physical or social aggression. Essentially, the curves for males and females were parallel for physical aggression, with males perpetrating more than females at all ages, and the curves for social aggression were not significantly different for males and females in terms of shape or magnitude.

Discussion

This study used multilevel growth curve models to document aggression trajectories during adolescence. Perpetration of physical and social aggression followed curvilinear trajectories from ages 11 to 18, with increases in each type of aggression followed by subsequent declines. Girls had significantly lower initial levels of physical aggression than boys at age 11, and boys consistently perpetrated more physical aggression than girls did, although the trajectories were parallel. There was no sex difference in the initial levels of

social aggression, and girls and boys perpetrated the same amount of social aggression at all ages studied.

As hypothesized, the trajectories for both physical and social aggression were curvilinear. These findings are similar to results from other studies that have observed curvilinear patterns of physical aggression (Farrell & Sullivan, 2004; Farrell et al., 2005), violence (Sampson et al., 2005), and delinquency (Windle, 2000) during adolescence, but they directly contradict studies that suggest a negative linear trend in adolescent aggression over time (Bongers et al., 2003; Cairns et al., 1989; Lauritsen, 1998). Additionally, the peak ages of involvement in physical and social aggression are comparable to the findings of Farrell and colleagues (2005), who determined that physical aggression peaked in seventh and eighth grade (ages 13 to 14) in two samples of adolescents from rural and urban areas. However, the peak ages for the outcomes in the current study were earlier than the peak ages documented by others for more serious violent behaviors. For example, Sampson and colleagues (2005) found the highest levels of violence among young adults to be between ages 17 and 18. The progression from perpetration of minor aggression to committing more serious acts of violence in samples of boys has been established by Loeber and Hay (1997) and Tolan, Gorman-Smith and Loeber (2000), among others. The timing of the increase in aggression for both boys and girls in the current study is consistent with the developmental patterns described by these other researchers, although future studies should seek to reproduce these findings in other samples of adolescents since the confidence intervals around the peak ages for this sample were wide (particularly for physical aggression).

In accordance with the hypotheses, social aggression began at higher levels and peaked 12 months earlier than physical aggression, although the confidence intervals for the peak ages did overlap. It is difficult to compare these findings to those of other researchers, since no studies have described developmental trajectories of social aggression during adolescence. Some research has suggested that social aggression develops later than physical

aggression (Pepler & Craig, 2005), since it is dependent upon the development of advanced social skills (Archer & Coyne, 2005). However, other studies show that social aggression begins to increase in late childhood or early adolescence (Connor, 2002; Xie, Cairns, & Cairns, 2005), which is what my findings suggest. It may be that there are two developmental peaks for physical aggression, one in early childhood (Connor, 2002) and one in adolescence (Connor, 2002; Moffitt, 1993), and that social aggression is most prevalent in between the two physical aggression stages. Variations in the conceptualization and measurement of social aggression also may contribute to the differences observed across studies. Social aggression is difficult to measure well among adolescents (Archer & Coyne, 2005), and some studies rely on teacher- or peer-reports of behavior, rather than asking adolescents to describe their own socially aggressive behaviors. Longitudinal studies spanning childhood and late adolescence are rare, but the contribution of such research to understanding the development of different forms of aggression would be substantial, particularly if they included multiple sources of data on physically and socially aggressive behaviors.

The negative correlation that I observed between the individual intercept and the linear slope suggests that adolescents who had higher initial levels of physical and social aggression showed slower linear increases in perpetration over time. This is predicted by Moffitt's (1993) developmental taxonomy of antisocial behavior, in that life-course persistent trajectories should start at high levels and stay high over time, demonstrating a high intercept and slow linear change. In contrast, Moffitt (1993) hypothesizes that adolescence-limited trajectories should start at lower levels but show a more rapid increase (and a more rapid deceleration) over time. Few trajectory studies have examined the correlation between initial levels and rates of change over time. In a study of delinquency during adolescence, Windle (2000) described trajectories in which the intercept was positively correlated with the linear slope but negatively correlated with the quadratic slope, which is somewhat

different from what Moffitt's taxonomy would suggest. Since I only had data from five points in time, I was unable to allow the quadratic slope to vary randomly; it is unclear whether there were individual differences in acceleration or deceleration over time in this sample.

The hypotheses about sex differences in the aggression trajectories were partially supported. There was a significant main effect of sex on initial levels of physical aggression, with males perpetrating more physical aggression than females, but there was no effect of sex on initial levels of social aggression. Physical aggression perpetrated by girls may be more likely to be sanctioned by peers and authorities such as teachers or parents than social aggression (Archer & Coyne, 2005; Crick, 1997; Xie, Swift et al., 2002), which may contribute to the sex differences in levels of physical aggression documented in this study and by others (Blum et al., 2000; Bongers et al., 2003; Farrell et al., 2000; Farrell et al., 2005; Fergusson & Horwood, 2002; Loeber & Hay, 1997; Sampson et al., 2005; Xie, Cairns et al., 2002). Most studies suggest that females engage in more social aggression than males (Archer & Coyne, 2005; Connor, 2002; Crick, 1997; Crick & Grotpeter, 1995; Xie, Swift et al., 2002), but the lack of a significant effect of sex on initial levels of social aggression that I documented is similar to the findings of Farrell and colleagues (2000) and Conway (2005). Future aggression research involving both children and adolescents should include measures of socially aggressive behaviors to further examine the impact of sex on the etiology of this type of aggression.

There was no support for the hypothesis regarding sex differences in the peak age of involvement in physical or social aggression. Other studies have shown that both males and females follow curvilinear trajectories of aggression and violence during adolescence (Farrell et al., 2005; Sampson et al., 2005). Farrell and colleagues (2005) also noted that there were no sex differences in the peak ages of involvement in either aggression or delinquency. Since few studies have explicitly examined the nature of sex differences in the development of

youth risk behaviors such as aggression, there is great promise for future investigations of this topic.

This study has several methodological strengths. First, a large census of adolescents completed five waves of questionnaires across three counties. The response rates for the in-school surveys were high, and the adolescent sample was demographically diverse. I also imputed missing data using multiple imputation procedures that used many established predictors of physical and social aggression to fill in missing values in order to minimize attrition bias. This study does have limitations that deserve mention. Using a predominantly rural sample from a localized area may have impacted the findings, and the generalizability of the results may be limited to similar contexts, particularly those with large populations of African-Americans or with lower median incomes than the national levels. However, I found levels of physical and social aggression that were similar to those documented in other studies with youth of similar ages (Farrell et al., 2000), and the trajectory patterns I documented resemble those from other studies.

Understanding sex differences in the development of different types of aggression during adolescence can guide public health researchers, policy makers and practitioners when developing prevention programs. For example, practitioners should include social and physical aggression in prevention programs for both males and females. The results also suggest that interventions should begin early to have the most impact on aggression during adolescence. By expanding the targeted behaviors and the audiences for prevention initiatives, it may be possible to alleviate the problem of youth aggression in the future.

PAPER 2: INFLUENCE OF NEIGHBORHOOD SOCIOECONOMIC DISADVANTAGE AND SOCIAL DISORGANIZATION ON TRAJECTORIES OF AGGRESSION DURING ADOLESCENCE: AN EXAMINATION OF MODERATED AND DIRECT EFFECTS

Abstract

Purpose: To describe trajectories of physical and social aggression for boys and girls and to determine whether neighborhood social disorganization moderates the relationship between neighborhood socioeconomic disadvantage and aggression trajectories during adolescence.

Methods: Five waves of data on youth aggression were collected through in-school surveys over 2.5 years. To describe the neighborhood context, data from the 2000 U.S. Census and from a random sample of parents were linked to each adolescent's Wave 1 U.S. Census block group. The sample (N=5118) was 50.1% female, 52.0% white and 38.3% African-American. The average age at Wave 1 was 13.1 years. Missing data were replaced using multiple imputation procedures, and the average trajectories were described using multilevel growth curve models.

Results: Perpetration of physical and social aggression followed curvilinear trajectories from ages 11 to 18, with the highest levels of aggression between ages 13 and 15. Counter to the hypotheses, there were no significant interactions between neighborhood socioeconomic disadvantage and social disorganization for either boys or girls when predicting trajectories of either outcome. For girls, neighborhood socioeconomic disadvantage was positively associated with initial levels of physical aggression. There were no significant main effects of

any of the neighborhood variables for social aggression for girls, and for boys, there were no significant main effects of any of the neighborhood variables in the multivariate models for either physical or social aggression. There was evidence of confounding of the effects of neighborhood socioeconomic disadvantage and neighborhood social disorganization for both boys and girls when predicting physical aggression.

Conclusions: Neighborhood risk had the strongest effects on physical aggression trajectories of adolescent girls. Research on sex differences in the effects of neighborhood risk factors on different types of aggression can inform public health research, practice and policy.

Keywords: adolescent, aggression, trajectory, neighborhood, growth curve, multilevel model

Introduction

Understanding which aspects of neighborhoods impact health, under what circumstances, and for whom is critical to advance adolescent health research. Neighborhood risk factors, particularly socioeconomic disadvantage and social disorganization, adversely impact many adolescent behaviors including sexual activity (Brewster, 1994; Upchurch, Aneshensel, Sucoff, & Levy-Storms, 1999), school dropout (Crowder & South, 2003), substance use (Chuang, Ennett, Bauman, & Foshee, 2005) and aggression (Farrington, 1998; Ingoldsby & Shaw, 2002; Jencks & Mayer, 1990; Kramer, 2000; Leventhal & Brooks-Gunn, 2000; Sorenson & Berk, 2001; Tatum, 2000; U.S. Department of Health and Human Services, 2001).

To better understand how neighborhoods influence youth risk behavior, I use multilevel growth curve analysis to investigate the moderated and direct influence of neighborhood socioeconomic disadvantage and neighborhood social disorganization on trajectories of physical and social aggression for boys and girls between ages 11 and 18. As recommended

by Cairns and colleagues (1989), I distinguish between physical aggression, which includes behaviors that threaten or cause physical harm to other people (Loeber & Hay, 1997), and social aggression, which encompasses forms of non-physical aggression that are focused on damaging social relationships rather than inflicting or threatening physical harm (Archer & Coyne, 2005). These two types of aggression have different relationships with psychosocial variables (Crick & Grotpeter, 1995; Xie, Swift et al., 2002), so I ascertain whether neighborhood effects are similar for these distinct types of aggression. I also examine the influence of neighborhood socioeconomic disadvantage and neighborhood social disorganization separately for boys and girls, since some studies have suggested that the development of aggression varies by sex (Cairns et al., 1989) and that the impact of the neighborhood environment on behavior may not be the same for all adolescent residents (Leventhal & Brooks-Gunn, 2000, 2003; Ramirez-Valles, Zimmerman, & Juarez, 2002).

Theories of Neighborhood Risk

Neighborhoods represent both physical and social environments, providing basic infrastructure and resources for education and growth, as well as social support, bonding opportunities and socialization structures for adolescents. Theories of social exclusion and relative deprivation emphasize the role of neighborhood socioeconomic disadvantage in adolescent development (Jencks & Mayer, 1990; Kramer, 2000). In many neighborhoods, discrimination and segregation limit residents' full participation in society by constraining economic prospects and other opportunities for the people who live there (Kramer, 2000; Wagle, 2002). As a result, risk conditions resulting from social exclusion, such as low levels of education, high unemployment rates and high poverty levels (Wagle, 2002), often cluster together in socioeconomically disadvantaged areas (Wilson, 1987). These risk conditions affect individuals directly through stress from chronic strain (Fitzpatrick & LaGory, 2000) and indirectly through frustration with blocked opportunity, social isolation, or changes in

social norms (Jencks & Mayer, 1990; Kramer, 2000; Wilkinson, Kawachi, & Kennedy, 1998; Wilson, 1987).

In addition to neighborhood socioeconomic disadvantage, neighborhood social disorganization is an import risk factor for youth aggression. Social disorganization is addressed by collective socialization models (Sampson et al., 2002; Wilcox, 2003) and social control and social learning theories (Baranowski et al., 2002; Kramer, 2000; Mazur, 1990), which emphasize the relational aspects and social processes in neighborhoods that impact adolescents. Collective socialization models posit that behaviors are promoted (or discouraged) through informal social controls by adults in the community (Wilcox, 2003), and that social bonds between members of a community can enhance the social control processes that deter deviance (Sampson et al., 2002). In socially disorganized neighborhoods with weak social bonds and low levels of social control, high levels of crime and violence are common (Ross & Jang, 2000; Sampson et al., 1997). In such environments, the social learning of aggression also may be increased, as adolescents exposed to violence and crime in their neighborhood learn that aggression is an acceptable problem-solving strategy and that deviant behavior will be tolerated (Farrington, 1998; Ingoldsby & Shaw, 2002; Mazur, 1990). The effects of neighborhood social disorganization on adolescent development may differ from the effects of neighborhood socioeconomic disadvantage (Gephart, 1997).

Neighborhood social disorganization has been conceptualized as a mediator of the effect of neighborhood socioeconomic disadvantage on general crime and violence (Sampson et al., 1997) and youth outcomes such as aggression (Leventhal & Brooks-Gunn, 2000; Sampson, 2001). However, some researchers have called for studies to determine whether the effects of neighborhood socioeconomic disadvantage on youth outcomes is moderated by social processes at the neighborhood level (Duncan & Aber, 1997; Duncan, Connell, & Klebanov, 1997; Ginther, Havman, & Wolfe, 2000; Leventhal & Brooks-Gunn, 2000; O'Campo, 2003).

For example, high levels of neighborhood social bonds and social control may alleviate negative effects of neighborhood socioeconomic disadvantage on youth development, whereas neighborhood crime may exacerbate any negative effects.

Neighborhood-level moderation has not been examined in detail, particularly in nonmetropolitan areas. The results from the few studies that have assessed interactions between neighborhood socioeconomic disadvantage and social disorganization suggest that this is an important question to examine in relation to aggression trajectories of youth in predominantly rural areas. Urban research suggests that high levels of social organization (represented by high levels of residential stability over time and strong interpersonal bonds among adults) in disadvantaged areas can actually increase crime rates (Warner & Rountree, 1997) and internalizing behaviors among young children (Caughy, O'Campo, & Muntaner, 2003). However, in nonmetropolitan areas, social organization appears to reduce crime rates in disadvantaged areas (Barnett & Mencken, 2002), and some urban studies also suggest a protective effect of social organization in disadvantaged areas when predicting child maltreatment rates (Garbarino & Sherman, 1980), patterns of adolescent delinquency (Gorman-Smith, Tolan, & Henry, 2000), and adolescents' affiliation with deviant peers (Brody et al., 2001). Although some of these studies examined moderation effects at the neighborhood level in relation to adolescent delinquency (Gorman-Smith et al., 2000) and area rates of violent crime and homicide (Barnett & Mencken, 2002; Warner & Rountree, 1997), no studies have investigated the multiplicative effect of neighborhood risk factors on the longitudinal development of aggression during adolescence.

Neighborhood Risk and Aggression Trajectories during Adolescence

Growth curve analysis examines processes of adolescent development using repeated measures of an outcome variable to examine average initial levels of the behavior as well as average rates of change (Raudenbush, 2001). In the case of curvilinear trajectories of

behaviors such as physical aggression (Aber et al., 2003; Farrell et al., 2005) and violence (Sampson et al., 2005) that increase and then decrease over time, peak ages of involvement are additional indicators of change that signal the point at which desistance begins. There is some evidence that suggests that neighborhood risk will affect patterns of physical aggression, but the influence of neighborhood factors on social aggression has not been documented.

Evidence of direct effects of neighborhood risk on the development of aggression comes in part from longitudinal studies, which suggest that an early age of onset of violence (Farrington, 1998; Loeber & Hay, 1997) and increases in aggression during adolescence (Farrington, 1998; Howell & Hawkins, 1998) are more likely in high-risk neighborhoods. Sampson and colleagues (2005) documented that neighborhood socioeconomic disadvantage and social disorganization in Chicago impacted average trajectories of violence committed during late adolescence and early adulthood, with both a lower prevalence of professional workers and higher levels of crime in a neighborhood increasing the propensity to commit violence. However, the authors did not describe the effect of the neighborhood risk factors on the average levels of change in violence perpetration over time.

Different analysis procedures such as growth mixture modeling (Nagin, 1999) have demonstrated that it is possible to disaggregate average behavioral trajectories and to distinguish between sub-groups that show similar patterns of development over time. The most common research using this technique is informed by Moffitt's (1993) developmental taxonomy of antisocial behavior, which suggests that offenders may follow two distinct trajectories: one characterized by adolescence-limited offending (indicated by an increase and then a decrease in antisocial behavior during adolescence) and the other represented by life-course persistent offending (indicated by high levels of antisocial behavior in childhood that continues throughout adolescence and into young adulthood). Research using this framework suggests that neighborhood factors can influence individual trajectories, with

both neighborhood socioeconomic disadvantage (Howell & Hawkins, 1998) and neighborhood social disorganization (Chung, Hill, Hawkins, Gilchrist, & Nagin, 2002) predicting membership in life-course persistent trajectory groups.

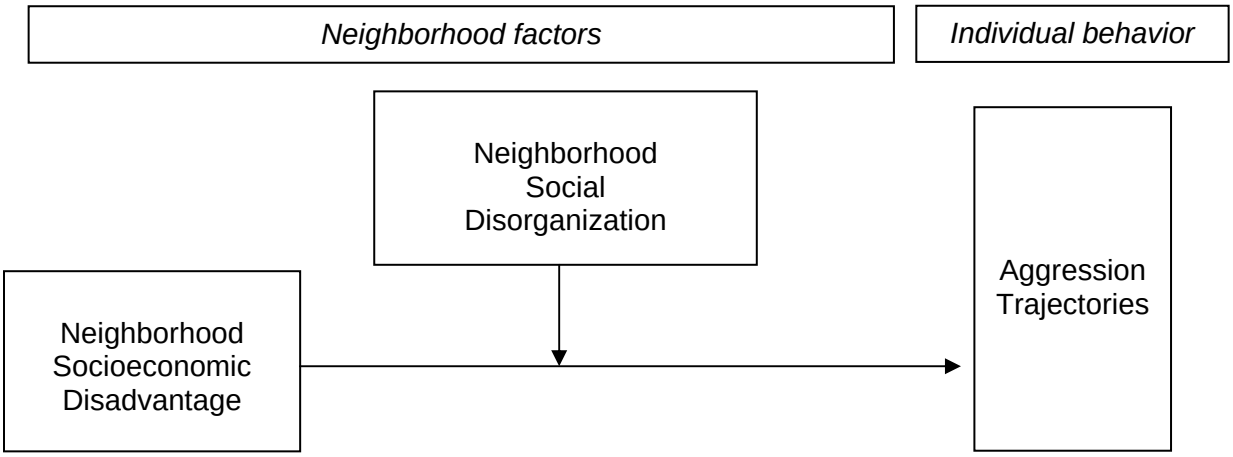
Although the evidence for direct effects of neighborhood risk on youth development is compelling, some studies suggest that moderation or suppression effects could impact the association between neighborhood risk factors and youth outcomes (Duncan & Aber, 1997; Ginther et al., 2000). For example, Osgood and Chambers (2000) noted that county-level socioeconomic disadvantage was not associated with juvenile violent crime arrest rates when controlling for levels of social disorganization. Conversely, Sampson, Morenoff and Raudenbush (2005) found that neighborhood collective efficacy was not a significant predictor of violence trajectories when indicators of socioeconomic disadvantage also were included in the models. However, no studies have examined interactions between neighborhood socioeconomic disadvantage and social disorganization related to trajectories of aggression during adolescence to assess the significance of moderation effects that could be influencing conclusions about neighborhood influence on development. In this study, I focus on the impact of the interaction of neighborhood socioeconomic disadvantage and social disorganization on trajectories of two types of aggression (both physical and social) during adolescence to assess the role of moderated and direct effects of neighborhood risk in the development of aggression among boys and girls during adolescence. I use adult-report measures of social disorganization (including indicators of social bonds between adults, social control and crime), as well as U.S. Census data on neighborhood socioeconomic disadvantage, to characterize the neighborhood context.

Research Aims and Hypotheses

To better understand the development of aggression among adolescents in nonmetropolitan areas, a preliminary aim of this study is to present the average

unconditional trajectories for physical and social aggression. Since boys and girls mature at different rates (Magnusson & Stattin, 1998) and few studies of the development of aggression have included girls, I present the unconditional trajectories using sex-stratified data. I expect the trajectories of physical and social aggression to be curvilinear for both boys and girls, with increases in aggression followed by declines over time.

Figure 2. Model of moderated neighborhood effects



The primary aim is to examine moderated and direct effects of neighborhood socioeconomic disadvantage and social disorganization on trajectories of physical and social aggression. (The conceptual model of moderated effects is presented in Figure 2.) I hypothesize that the interaction between neighborhood socioeconomic disadvantage and social disorganization will affect the intercept, rates of change and peak age of involvement in aggression, with higher intercepts, faster rates of change and later peak ages of involvement suggestive of problematic aggressive behavior during adolescence (Moffitt, 1993; Nagin, 1999; Nagin & Tremblay, 2001). Specifically, neighborhood social disorganization is expected to amplify the negative effects of neighborhood socioeconomic disadvantage, such that the impact of a given level of disadvantage on the trajectories of

physical and social aggression will be more profound as the level of social disorganization rises. The highest initial levels of aggression, fastest increases and latest peak ages of involvement are expected in those neighborhoods that are both socioeconomically disadvantaged and socially disorganized. The conditional trajectories also use sex-stratified data; however, I do not make separate hypotheses for boys and girls because there is not enough evidence to support such distinctions.

Methods

Study Design

The data are from the longitudinal, school-based Context of Adolescent Substance Use Study, which was designed to investigate contextual influences on adolescent substance use and aggression, with a focus on peer networks, family characteristics and neighborhood factors (Ennett et al., 2006). The study included adolescents from the public schools in three counties in North Carolina that are classified as nonmetropolitan areas with access to an interstate highway and are eligible for targeted federal funds for health services due to their rural location (Ricketts et al., 1999). These counties also have greater proportions of African-Americans (M = 27.8%) than does the general United States population (12.2%), and the median household income (M = $36,600) and median housing value (M = $89,400) are lower than the national medians ($42,000 and $111,800, respectively) (U.S. Census Bureau, 2002).

The Context of Adolescent Substance Use Study consists of three components: (1) in-school surveys with adolescents (county-wide census), (2) telephone interviews with a randomly sampled cohort of parents, and (3) linking U.S. Census data with geocoded addresses. Eligible students completed fives waves of questionnaires in the schools (average response rate: 81.1%), and parents participated in three sets of telephone interviews (average response rate: 78.0%). Addresses from students who completed questionnaires and from

parents who completed interviews were geocoded at each wave (average success rate: 87.6%). This analysis includes youth-report data on aggression, as well as parent-report data on the neighborhood context and U.S. Census data linked to block group geocodes. The Public Health Institutional Review Board at The University of North Carolina at Chapel Hill approved all study protocols.

In-School Surveys

Five waves of data were collected from adolescents in schools every 6 months between spring 2002 and spring 2004, beginning when the students were in sixth, seventh or eighth grade and ending when they were in eighth, ninth or tenth grade. At each wave, all adolescents in the public schools in the three study counties were eligible for participation (approximately 6,100 students) except those who could not complete the questionnaire in English (approximately 15 students) and those who were in special education programs (approximately 300 students). At each wave, new students who met the inclusion criteria entered the study.

Parents were notified about the study and had the opportunity to refuse consent for their child's participation at the beginning of each academic year and whenever a new student became eligible for the study. At each wave, trained research assistants administered questionnaires on at least two different occasions at each school to allow those students who had been absent on the primary day of data collection to participate in the study on the make-up day. To maintain confidentiality, teachers remained at their desks while the students completed their questionnaires, and the students placed their questionnaires in envelopes before returning them to the data collectors.

Parent Interviews

A random sample of parents was selected to complete telephone interviews. The parent was eligible if the child had completed a Wave 1 questionnaire, if they had only one child in

the school-based study and if they could complete the interview in English (N=2062). Trained interviewers first attempted to reach each adolescent's mother or an adult female living with the adolescent, and if no mother figure could be identified, the father or an adult male living with the adolescent completed the interview. Interviews lasted approximately 25 minutes, and all participating parents received a $10 incentive check by mail. During the spring and summer of 2002, 1663 parents (80.7%) completed the Wave 1 interviews.

Address Geocoding

Neighborhoods are defined by U.S. Census block group boundaries. Although it is a common practice, using Census geographies to represent neighborhoods has been criticized for failing to represent neighborhood communities as perceived by residents (Earls & Carlson, 2001). However, local communities work with the Census Bureau to define boundaries based on defining physical features (such as major streets) as well as social or ethnic characteristics of the area (Leventhal & Brooks-Gunn, 2000), and studies have found that U.S. Census block groups can adequately represent neighborhoods and delineate different social and structural factors between different neighborhoods (Cook et al., 1997; Krieger et al., 2002).

Student and parent addresses were sent to a commercial geocoding firm to be matched with U.S. Census tracts and block groups. The parent addresses were geocoded to permit linkage of additional neighborhood measures with the students' data. The geocode matches varied in precision from the most precise street address matches to the least precise 5-digit ZIP centroid matches. Addresses that were not matched at the street level were cleaned and checked using the U.S. Postal Service website (U.S. Postal Service, n.d.) and a general address mapping website (MapQuest, n.d.), and then a second attempt was made to geocode them using either ArcGIS software (ESRI, 2005) or the U.S. Census American FactFinder website (U.S. Census Bureau, n.d.). The final geocode for each address was assigned based

on the results of all geocoding attempts such that street matches were preferred over ZIP centroid matches.

As recommended by Krieger and colleagues (2001), an accuracy study was conducted to evaluate the geocodes returned by the commercial firm and those generated using the ArcGIS software. The accuracy study consisted of a random sample of street matches, stratified by county, generated using a SAS survey selection program (SAS Institute, 2003). The sample of addresses was re-geocoded using the American FactFinder website, which represented the gold standard (Krieger et al., 2001). Overall, 90.4% of the addresses checked for accuracy matched the gold standard perfectly and an additional 4.3% matched at the tract level but not at the block group level.

Analysis Sample

The analysis sample (N=5118) includes those adolescents who completed a Wave 1 questionnaire, except for those who were younger than 11 or older than 16.5 at Wave 1 (n=26), those who did not give their birth date or sex on any of the questionnaires (n=8), those without a Wave 1 block group geocode (n=35), and those who were the only respondent from their Wave 1 block group (n=33). The age restriction was imposed to limit the number of students who were out of the typical age range for their grade. I limited the analyses to block groups containing more than one student to increase the stability of the neighborhood estimates.

Overall response rates for the analysis sample ranged from 86.6% at Wave 2 to 79.5% at Wave 5. Of the students in the sample, 56.0% participated in the study at all five waves, 15.6% participated in four waves, 15.1% in three waves, 5.3% in two waves only and 8.0% only at Wave 1. Procedures for imputing missing data are described below.

At Wave 1, the majority of students (95.6%) were between the ages of 11 and 14 (M=13.1 years). Half (50.1%) of the students were females, 52.0% were white, 38.3% were black or

African-American, 3.8% were Hispanic or Latino, and 5.9% were another race or ethnicity. Most students (80.0%) indicated that they lived with two parents (biological or step-parents), and 73.0% reported that at least one parent had attended college, community college or technical school. At Wave 1, approximately half of the students had perpetrated physical aggression (45.6% of girls and 51.8% of boys) and more than two-thirds had perpetrated social aggression (71.0% of girls and 68.3% of boys).

The student geocodes represented each of the 113 block groups in the three-county area. A small group (1.2%) had geocodes from counties outside the target area, resulting in a total sample of 128 block groups. There were between 2 and 63 students in each block group. The parent geocodes also represented all of the block groups in the three county area, with between 2 to 39 parents in each block group. Each of the 128 block groups from the student sample were represented by at least two parent respondents. According to the U.S. Census (2002), the block groups ranged in size from 461 to 3581 people (M=1566, SD=620).

Measures

As described below, this study models both aggression outcomes as a function of chronological age. To reduce errors associated with birth dates reported incorrectly by younger respondents, age was calculated based on the modal birth date (modal month, modal day and modal year) for all available waves of data, and it was centered by subtracting 11 (the youngest age in the sample at Wave 1) so that the intercepts could be easily interpreted.

Aggression

Physical and social aggression were measured at all five waves. The physical aggression scale (Farrell et al., 2000) assessed how many times in the past three months the respondent had been in a fight in which someone was hit, hit or slapped another kid, threatened to hurt a teacher, and threatened someone with a weapon. Social aggression included the following

items: excluded another student from his or her group of friends, spread a false rumor about someone, picked on someone, and started a fight between other people (Farrell et al., 2000). The responses for each item were *none* (0), *1-2 times* (1), *3-5 times* (2), *6-9 times* (3), or *10 or more times* (4). The responses were summed to form a continuous total score for each type of aggression, such that higher scores indicated higher levels of aggression. The Cronbach's alpha ranged from .68 for both the physical aggression scale (M=1.27, SD=2.03) and the social aggression scale (M=2.09, SD=2.48) at Wave 1 to .86 for the physical aggression scale (M=1.36, SD=2.94) and .83 for the social aggression scale (M=2.05, SD=3.20) at Wave 5. To adjust for skewness, the total aggression scores were log-transformed after adding a constant.

Neighborhood Variables

The neighborhood data linked to the adolescents' block group geocodes came from two sources: the 2000 U.S. Census (U.S. Census Bureau, 2002) and parents' perceptions of the neighborhoods (gathered during the Wave 1 telephone interviews). All neighborhood-level covariates are grand-mean centered, so that the intercept and slope terms represent the averages across neighborhoods (Raudenbush & Bryk, 2002; Singer, 1998). Because I used sex-stratified data in the analyses, the grand means were calculated separately for boys and girls. Correlation coefficients between the neighborhood variables and physical and social aggression are shown in Table 4.

Neighborhood socioeconomic disadvantage. Neighborhood socioeconomic disadvantage was calculated using U.S. Census data, and it encompasses three dimensions: education (percentage of people aged 25 and older with less than a high school education), employment (percentage of people aged 16 or older in the labor force who were unemployed and the percentage of people aged 16 or older who held working-class or blue-collar jobs) and economic resources (percentage of people living below the federally-defined poverty

threshold, percentage of households without access to a car, and the percentage of renter-occupied housing units). Working-class or blue-collar jobs included the following: healthcare support; food preparation and serving; building and grounds cleaning and maintenance; personal care and service; sales and office work; construction, extraction and maintenance; and production, transportation and material moving occupations (Deane & Shin, 2002; Krieger et al., 2002). The federal poverty threshold was about $17,029 for a family of four in 1999, according to the poverty guidelines updated periodically in the Federal Register by the U.S. Department of Health and Human Services. A mean socioeconomic disadvantage score was calculated for each block group (M=25.34, SD=8.52), and each student was assigned their block group average. Higher scores indicate higher levels of neighborhood socioeconomic disadvantage. The Cronbach's alpha for the six items was .88 for the study sample.

Neighborhood social disorganization. Neighborhood social disorganization is represented by three dimensions: neighborhood social bonding, social control and crime. Details about the items in each scale are included below. To minimize possible biases associated with the demographic composition of the block groups, I calculated the values for the parent reports of neighborhood social disorganization using a latent variable approach (Raudenbush, 2003). I conducted principle components analyses of the items on each scale, extracted factor scores for each respondent, and used the factor scores in a mixed model that accounted for the respondent's demographic characteristics (age, sex, race/ethnicity, level of education, homeowner status and logged length of residence in the home) to determine the average level of the three components of neighborhood social disorganization in each block group (Raudenbush, 2003; Sampson & Raudenbush, 2004).

Neighborhood social bonding. Parents responded to four items based on the work of Parker and colleagues (2001) to indicate how often in the past three months they had socialized with one or more neighbors, asked one of their neighbors for help, talked to a

neighbor about personal problems, or gone out for a social evening with a neighbor. Responses included *never, once or twice, two or three times,* or *four or more times* and were scored from 1 to 4. The Cronbach's alpha at the individual level was .75 at Wave 1. High scores indicate greater social bonding among adults in the neighborhood.

Neighborhood social control. Parents responded to six items about the degree of social control in their neighborhood (Sampson et al., 1997). They indicated how likely it is that neighbors would step in and do something if teens were damaging property, teens were showing disrespect to an adult, a fight broke out in front of someone's house, teens were hanging out and smoking cigarettes, teens were hanging out and drinking alcohol, and teens were hanging out and smoking marijuana. Responses ranged from 1 (*very unlikely*) to 4 (*very likely*). The Cronbach's alpha at the individual level for these six items was .91 at Wave 1. High scores indicate an effective social control process in the neighborhood.

Neighborhood crime. Eight items represent neighborhood crime and safety. Parents responded to four dichotomous items about crime in their neighborhood in the three months preceding the interview. The items assessed whether or not they had seen someone get arrested, drug deals, someone being beaten up, or someone pull a gun on another person (*yes* = 1). The parents also indicated how safe they feel walking in their neighborhood during the daytime and after dark (response options for these items: *very safe, fairly safe, a little unsafe, very unsafe*), as well as the degree to which they agreed or disagreed with the following statements: "there is too much drug use in my neighborhood" and "there is a lot of crime in my neighborhood" (4-point Likert scale, with high scores for *strongly agree*). The Cronbach's alpha at the individual level at Wave 1 for these items was .79. High scores indicate higher levels of neighborhood crime.

Control Variables

The control variables included race/ethnicity, parent education, family structure, the number of times the student moved across the five waves of data collection, the type of address geocoded and the precision of the block group geocode match. I determined values for the demographic control variables based on all available data across the five waves of surveys. The child's self-reported race or ethnicity was based on the modal response across all waves, and it was represented by three mutually-exclusive dummy variables (black or African-American, Hispanic or Latino, or other race/ethnicity) with white as the reference category. Parent education was measured by the highest level of education attained by either parent, and it included *less than a high school education* (0), *graduated from high school* (1), *some college, community college or technical school* (2), *graduated from community college or technical school* (3), *graduated from college* (4), and *graduate or professional school after college* (5). Family structure was a dichotomous variable indicating residence in a single-parent household at any time during the study (1) compared to continuous residence in a two-parent household (0). A dichotomous variable represented the type of address geocoded (PO Box = 1; street address = 0). The degree of precision of the geocode match ranged from 5-digit ZIP Code centroid matches (0) to a street-level match (2). The analyses also controlled for the number of times the student moved to a different block group during the five-wave study, with higher numbers representing more moves.

Missing Data

Missing values are common in longitudinal research with adolescents (Faden et al., 2004). To minimize the possible impact of attrition bias that can arise from using complete-case analysis in longitudinal studies, missing values were replaced using multiple imputation procedures (Rubin, 1987). First, I specified a missingness equation to guide the imputation. This equation included the dependent variables at all five waves, the independent variables,

variables highly correlated with the outcomes from all five waves, variables containing special information about the sample and other variables thought to be associated with missingness (Allison, 2000; Horton & Lipsitz, 2001; Patrician, 2002).

All of the variables included in the imputation were either continuous or dichotomous (Allison, 2005), and I confirmed that the variables were not collinear using eigenanalysis (Belsley et al., 1980) and by examining variance inflation factors (Neter et al., 1990). I used SAS PROC MI (SAS Institute, 2003) to impute the missing values based on the missingness equation using the Markov Chain Monte Carlo (MCMC) specification (Yuan, 2000). I bounded the imputed values to the valid ranges of the data, and I allowed all imputed dichotomous variables to range between 0 and 1 rather than rounding the values, in accordance with the recommendations of Allison (2005).

The analysis results were combined across the ten imputed datasets using SAS PROC MIANALYZE (Horton & Lipsitz, 2001), which accounts for the uncertainty of the imputation process when calculating summary test statistics, parameter estimates and standard errors. All models had relative efficiencies greater than .95, which suggests that the number of imputations was sufficient to achieve stable estimates (Horton & Lipsitz, 2001).

Analysis Strategy

I used multilevel growth curves to model the average trajectories for each outcome (physical and social aggression) between ages 11 and 18. The data were stratified by sex and parallel analyses were conducted for each stratum. All analyses were conducted using PROC MIXED in SAS version 9.1 on a SunOS 5.9 platform (SAS Institute, 2003) using a restricted maximum likelihood estimation process and the Kenward-Roger adjustment of the standard errors and degrees of freedom for more conservative tests of the fixed effects (Kenward & Roger, 1997). Because the MIANALYZE procedure does not include the covariance parameters from mixed models, I combined the covariance parameters from the

unconditional models across the ten imputed datasets using the formulas provided by Rubin and Schafer (1997).

Multilevel Models

Random effects models (including multilevel models and latent growth curve analyses) are used to describe trajectories of behavior and to assess predictors of those trajectories (Curran & Willoughby, 2003; Guo & Hipp, 2004; Raudenbush & Bryk, 2002). The basic multilevel growth model can be specified as:

$$\mathbf{Y_{tij} = \pi_{oij} + \pi_{1ij}(AGE)_{tij} + \pi_{2ij}(AGE^2)_{tij} + e_{tij}} \quad \text{for girls: i=1,...,2565; j=1,...128; for boys: i=1,...,2553; j=1,...128} \quad (1)$$

$$\mathbf{\pi_{pij} = \beta_{poj} + \sum_{q=1}^{Q_p} \beta_{pqj} X_{qij} + r_{pij}} \quad p=0, 1, 2 \quad (2)$$

$$\mathbf{\beta_{pqj} = \gamma_{pqo} + \sum_{s=1}^{S_{qp}} \gamma_{pqs} W_{sj} + u_{pqj}} \quad p=0, 1, 2;\ q=0, 1,...Q_p \quad (3)$$

The level-1 model (1) denotes change over time within individuals. In this study, Y_{tij} represents the observed aggression score at age t for child i in neighborhood j, and it is a function of a quadratic curve plus random error (e_{tij}). Thus, π_{oij} is the total aggression score of child$_{ij}$ at age 11, π_{1ij} is the linear slope for child$_{ij}$, and π_{2ij} is the quadratic slope for child$_{ij}$.

The level-2 models (2) denote differences between individuals within neighborhoods, and they are used to predict the parameters from the level-1 model. For this study, β_{poj} is the intercept for neighborhood j in modeling the child effect π_{pij}, where X_{qij} is one of the Q_p individual-level control variables characteristic of child i in neighborhood j. β_{pqj} represents the effect of X_{qij} on the pth growth parameter, and r_{pij} is the random effect for each child. Based on preliminary analyses (not shown), I allowed the demographic control variables (race/ethnicity, parent education and family structure) to predict the intercept and the linear

slope, but not the quadratic slope, from the level-1 model. The geocoding control variables (type of address geocoded, precision of the geocode match and the number of moves) only predicted the level-1 intercept.

The level-3 models (3) denote differences between neighborhoods, and they are used to predict the parameters from the level-2 models. Each β_{pqj} is predicted by the neighborhood-level characteristics, where γ_{pqo} is the intercept in the neighborhood-level model for β_{pqj}, W_{sj} is a neighborhood characteristic used as a predictor for the neighborhood effect on β_{pqj}, γ_{pqs} is the level-3 coefficient that represents the direction and strength of the association between neighborhood characteristic W_{sj} and β_{pqj}, and u_{pqj} is a random effect for each neighborhood. Neighborhood socioeconomic disadvantage, three variables representing neighborhood social disorganization, and the interaction between socioeconomic disadvantage and each of the social disorganization variables were specified as predictors of the intercept and linear and quadratic slopes from the level-2 model.

The analyses used sex-stratified data, and the models for boys and girls differed slightly, as described below. The preliminary models included four random effects (neighborhood intercept, u_{00j} [$u_{10j} = 0$ and $u_{20j} = 0$]; individual intercept, r_{0ij}; individual linear slope, r_{1ij}; and individual quadratic slope, r_{2ij}), but not all of the random effects were estimable, which suggests that there were more random effects than the data could support given the limited number of time points per subject. For girls, all of the random effects were estimable once the random individual quadratic slope was dropped from the model (i.e. at level 2, $r_{2ij} = 0$). Thus, I included three random effects in the models for girls, and I allowed the level-2 random effects to correlate. After I dropped the random quadratic slope for boys (i.e. at level 2, $r_{2ij} = 0$), additional analyses determined that the neighborhood clustering effect in the boys' data was at or near zero, so at level 3, I also set $u_{00j} = 0$. Thus, I included two random effects in the final models for boys, which were allowed to correlate. At the individual level, the random effects indicate variability of individual trajectories (the within-person models).

At the neighborhood level, the random effects indicate the level of variability across the different neighborhoods in the sample.

Analyses to Test Study Hypotheses

Unconditional Models. Although there are many metrics for the passage of time in longitudinal studies (Curran & Willoughby, 2003), to be consistent with prior research on youth aggression, I modeled both outcomes as a function of chronological age, including a quadratic term, using sex-stratified data. The unconditional models describe the average physical and social aggression trajectories for boys and girls from age 11 to age 18. I used joint hypothesis tests of the linear and quadratic slopes (block *F*-tests) to confirm that the trajectories were curvilinear. Under a quadratic model, the peak age is obtained from the first derivative using a ratio of the regression coefficients ($-B_{age}/2B_{age\text{-}squared}$). A Taylor series approximation (the delta method) was used to obtain the standard error of the estimated peak age (Sen & Singer, 1993).

For girls, I calculated intraclass correlation coefficients (ICCs) based on the unconditional models to describe the proportion of variance in physical and social aggression that occurs between neighborhood block groups (Singer, 1998). Because the models include random individual-level age effects, the ICCs vary by age. I calculated the ICCs for ages 11 and 18, which were the youngest and oldest ages in the sample.

Moderation Analyses. Conditional models were used to determine whether neighborhood social disorganization moderated the relationship between neighborhood socioeconomic disadvantage and trajectories of physical and social aggression. Significant two-way interactions between neighborhood socioeconomic disadvantage and the three variables representing neighborhood social disorganization indicate an impact on the intercept. Significant three-way interactions between the time variables (age or age-squared), neighborhood socioeconomic disadvantage and the three variables representing

neighborhood social disorganization represent the influence of the interactions on the rate of change over time and the peak age of involvement in aggression.

All moderators were entered into the model simultaneously, and the variables were evaluated in blocks: (1) age, age-squared, neighborhood variables, and control variables (main effects and interactions of the demographic control variables with age); (2) three 2-way neighborhood product terms; (3) four 2-way interactions involving age and the neighborhood variables; (4) four 2-way interactions involving age-squared and the neighborhood variables; (5) four 3-way interactions involving age and the neighborhood product terms; and (6) four 3-way interactions involving age-squared and the neighborhood product terms. The conditional models were simplified using backwards elimination (starting with block 6) to remove any blocks that were not statistically significant. The contribution of each block to the model was assessed using a multivariate *F*-test to limit the overall Type 1 error level to .05 to account for the multiple inferences being made.

Main Effects of Neighborhood Variables. I calculated bivariate correlation coefficients between time-varying values of physical and social aggression and the neighborhood variables at Wave 1, using the formulas provided by Rubin and Schafer (1997) to combine the estimates across the ten imputed datasets. When there were no significant interactions between neighborhood socioeconomic disadvantage and social disorganization, I examined the individual main effects of each neighborhood variable on the intercepts and slopes of the aggression trajectories using conditional growth curve models that included interactions of the neighborhood factor with age and age-squared, using backwards elimination to simplify the models by removing nonsignificant interaction terms. All conditional models included the demographic control variables and their interactions with age, which were not trimmed from the models.

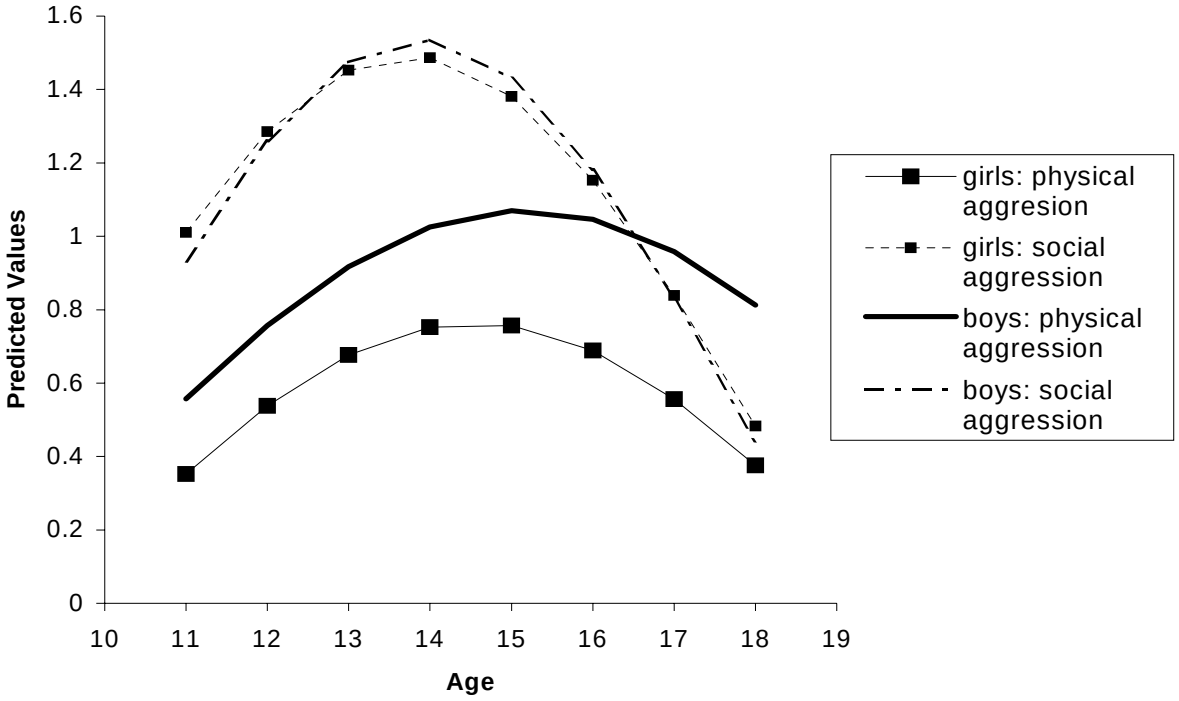
Results

Unconditional Trajectories of Physical and Social Aggression

The sex-stratified unconditional models are presented in Table 5. The joint *F*-tests of the linear and quadratic slopes for physical aggression (F (2, 143.7) = 16.47, $p < .01$, for boys, and F (2, 105.4) = 19.79, $p < .01$, for girls) and social aggression (F (2, 149.7) = 29.53, $p < .01$, for boys, and F (2, 161.5) = 25.92, $p < .01$, for girls) and the direction of the coefficients (significant positive linear slopes and significant negative quadratic slopes) confirmed that the trajectories for both physical and social aggression were curvilinear for both boys and girls. Initial increases in physical aggression were followed by declines after age 15.2 for boys and after age 14.6 for girls, and initial increases in social aggression were followed by declines after age 13.8 for boys and after age 13.7 for girls. The average physical and social aggression trajectories are depicted in Figure 3. There was some discrepancy between the predicted and observed values of aggression at the oldest ages included in the study (not shown), which may have been due to the small numbers of participants who were older than 16 years old.

Description of the random effects also comes from the unconditional models. For physical aggression, the variances of all random effects were significant for both boys and girls, with significant variation between individuals in the initial levels of physical aggression and in the linear change over time. For girls, there also was significant variation between neighborhoods in the initial levels of physical aggression. For social aggression, the variances of all individual-level random effects were significant for both boys and girls, with significant variation between individuals in the initial levels of social aggression and in the linear change over time. The variance of the random neighborhood intercept was not significant for girls, indicating that there was not a significant level of variation between neighborhoods in the initial levels of social aggression.

Figure 3. Sex-stratified trajectories of physical and social aggression from ages 11 to 18



For girls, the intraclass correlation coefficients suggest that the proportion of variance in physical aggression occurring between neighborhoods (7.6% at age 11 and 1.5% at age 18) was much greater than the proportion of variance in social aggression that occurred between neighborhoods (0.7% at age 11 and 0.9% at age 18). This indicates that there was less clustering of social aggression by neighborhood block groups, which is consistent with the description of the random neighborhood intercepts above. The proportion of variance in physical aggression occurring between neighborhoods was much greater at age 11 than at age 18. As previously noted, there was a near-zero level of clustering of the boys' data by neighborhood.

Table 4. Bivariate correlations between neighborhood constructs and aggression outcomes.

	(1)	(2)	(3)	(4)	(5)	(6)
(1) Physical aggression	---	.71**	.05**	-.04**	-.02*	.04**
(2) Social aggression	.61**	---	-.01	-.01	.01	-.01
(3) Neighborhood socioeconomic disadvantage	.12**	.02	---	-.42**	-.57**	.71**
(4) Neighborhood social bonds	-.06**	-.01	-.40**	---	.48**	-.38**
(5) Neighborhood social control	-.05**	.01	-.55**	.47**	---	-.68**
(6) Neighborhood crime	.10**	.01	.71**	-.37**	-.67**	---

Note. Males (N=2553) above diagonal; females below (N=2565).

* $p < .05$. ** $p < .01$.

Table 5. Sex-stratified unconditional models of physical and social aggression from age 11 to age 18

	Boys (N=2553)				Girls (N=2565)			
	Physical Aggression		Social aggression		Physical Aggression		Social aggression	
	B	95% CI	B	95% CI	B	95% CI	B	95% CI
Fixed effects								
Intercept	0.44	(0.36, 0.53)	0.66**	(0.57, 0.75)	0.30**	(0.23, 0.38)	0.70**	(0.62, 0.78)
Age	0.14**	(0.08, 0.19)	0.19**	(0.13, 0.25)	0.15**	(0.10, 0.19)	0.16**	(0.11, 0.21)
Age-squared	-0.02**	(-0.03, -0.01)	-0.03**	(-0.04, -0.02)	-0.02**	(-0.03, -0.01)	-0.03**	(-0.04, -0.02)
Random effects								
Individual intercept	0.28*	(0.20, 0.36)	0.43*	(0.33, 0.53)	0.23*	(0.17, 0.28)	0.41*	(0.33, 0.48)
Individual linear slope	0.02*	(0.01, 0.03)	0.03*	(0.02, 0.04)	0.01*	(0.01, 0.02)	0.02*	(0.02, 0.03)
Neighborhood intercept	---	---	---	---	0.02*	(0.01, 0.03)	0.00	(0.00, 0.01)
Peak age (years)	15.16	(13.41, 16.91)	13.87	(13.09, 14.64)	14.56	(13.77, 15.34)	13.74	(13.17, 14.31)

Note. CI = confidence interval.

* $p < .05$. ** $p < .01$.

Table 6. Neighborhood effects on trajectories of physical and social aggression from age 11 to age 18 (reduced conditional models)

	Boys (N=2553)				Girls (N=2565)			
	Physical Aggression		Social aggression		Physical Aggression		Social aggression	
	B	95% CI	B	95% CI	B	95% CI	B	95% CI
Intercept	0.331**	(0.145, 0.516)	0.566**	(0.351, 0.781)	0.297**	(0.126, 0.469)	0.681**	(0.487, 0.874)
Age	0.103**	(0.031, 0.174)	0.168**	(0.091, 0.244)	0.138**	(0.088, 0.189)	0.154**	(0.098, 0.210)
Age-squared	-0.017**	(-0.026, -0.008)	-0.033**	(-0.043, -0.023)	-0.021**	(-0.027, -0.014)	-0.028**	(-0.036, -0.020)
Socioeconomic disadvantage	0.001	(-0.003, 0.005)	0.001	(-0.003, 0.005)	0.006**	(0.002, 0.010)	0.003	(-0.002, 0.007)
Social bonding	-0.244	(-0.662, 0.174)	-0.406	(-0.861, 0.049)	0.013	(-0.436, 0.463)	-0.033	(-0.526, 0.459)
Social control	0.064	(-0.078, 0.205)	0.126	(-0.037, 0.289)	0.115	(-0.036, 0.266)	-0.028	(-0.191, 0.135)
Crime	0.052	(-0.042, 0.146)	0.042	(-0.063, 0.147)	0.035	(-0.062, 0.133)	-0.029	(-0.136, 0.078)

Note. CI = confidence interval. All analyses controlled for race/ethnicity, parent education, family structure, the number of times the student moved across the five waves of data collection, the type of address geocoded and the precision of the block group geocode match.

* $p < .05$. ** $p < .01$.

Table 7. Individual neighborhood main effects models predicting trajectories of physical and social aggression from age 11 to age 18

	Boys (N=2553)				Girls (N=2565)			
	Physical Aggression		Social aggression		Physical Aggression		Social aggression	
	B	95% CI	B	95% CI	B	95% CI	B	95% CI
Model 1:								
Intercept	0.330**	(0.145, 0.516)	0.567**	(0.352, 0.781)	0.301**	(0.131, 0.471)	0.678**	(0.486, 0.870)
Age	0.103**	(0.032, 0.174)	0.168**	(0.092, 0.245)	0.138**	(0.088, 0.189)	0.154**	(0.098, 0.210)
Age-squared	-0.017**	(-0.026, -0.008)	-0.033**	(-0.043, -0.023)	-0.021**	(-0.027, -0.014)	-0.028**	(-0.036, -0.020)
Socioeconomic disadvantage	0.003†	(-0.001, 0.006)	0.001	(-0.002, 0.004)	0.005**	(0.003, 0.008)	0.002	(-0.001, 0.005)
Model 2:								
Intercept	0.324**	(0.139, 0.509)	0.567**	(0.352, 0.782)	0.275**	(0.104, 0.446)	0.666**	(0.475, 0.857)
Age	0.103**	(0.032, 0.174)	0.168**	(0.092, 0.245)	0.138**	(0.087, 0.188)	0.154**	(0.098, 0.210)
Age-squared	-0.017**	(-0.026, -0.008)	-0.033**	(-0.043, -0.023)	-0.020**	(-0.027, -0.014)	-0.028**	(-0.036, -0.020)
Social bonding	-0.298	(-0.673, 0.077)	-0.315	(-0.721, 0.092)	-0.178	(-0.603, 0.246)	-0.146	(-0.587, 0.295)

(cont.)

Table 7. (Continued)

	Boys (N=2553)				Girls (N=2565)			
	Physical Aggression		Social aggression		Physical Aggression		Social aggression	
	B	95% CI	B	95% CI	B	95% CI	B	95% CI
Model 3:								
Intercept	0.321**	(0.137, 0.507)	0.559**	(0.344, 0.773)	0.277**	(0.106, 0.448)	0.669**	(0.478, 0.861)
Age	0.103**	(0.032, 0.175)	0.168**	(0.092, 0.245)	0.138**	(0.087, 0.189)	0.154**	(0.098, 0.210)
Age-squared	-0.017**	(-0.026, -0.008)	-0.033**	(-0.043, -0.023)	-0.020**	(-0.027, -0.014)	-0.028**	(-0.036, -0.020)
Social control	-0.044	(-0.146, 0.058)	0.019	(-0.096, 0.135)	-0.038	(-0.156, 0.079)	-0.052	(-0.171, 0.067)
Model 4:								
Intercept	0.326**	(0.141, 0.512)	0.564**	(0.350, 0.779)	0.283**	(0.112, 0.453)	0.668**	(0.477, 0.859)
Age	0.103**	(0.032, 0.174)	0.168**	(0.092, 0.245)	0.138**	(0.087, 0.188)	0.154**	(0.098, 0.210)
Age-squared	-0.017**	(-0.026, -0.008)	-0.033**	(-0.043, -0.023)	-0.020**	(-0.027, -0.014)	-0.028**	(-0.036, -0.020)
Crime	0.059†	(-0.006, 0.124)	0.024	(-0.044, 0.092)	0.080*	(0.015, 0.145)	0.024	(-0.046, 0.094)

Note. CI = confidence interval. All analyses controlled for race/ethnicity, parent education, family structure, the number of times the student moved across the five waves of data collection, the type of address geocoded and the precision of the block group geocode match.

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

Moderated Effects of Neighborhood Risk Factors

None of the interactions between neighborhood socioeconomic disadvantage and the three indicators of neighborhood social disorganization were statistically significant for physical or social aggression for either boys or girls. For both boys and girls, the final reduced models for both outcomes were main effects models containing no interaction terms. Thus, there was no support for the hypotheses regarding the effect of interactions between neighborhood socioeconomic disadvantage and neighborhood social disorganization on the intercepts or linear slopes of the trajectories or on the peak ages of involvement in physical or social aggression.

The reduced conditional models (Table 6) indicate that, when controlling for levels of neighborhood social disorganization, neighborhood socioeconomic disadvantage was positively associated with initial levels of physical aggression for girls. For girls, levels of physical aggression at age 11 increased as the level of neighborhood socioeconomic disadvantage increased. There was no significant effect of neighborhood socioeconomic disadvantage on the linear or quadratic slopes of the girls' physical aggression trajectories. Thus, the shapes of the individual physical aggression trajectories for girls were the same across different levels of neighborhood socioeconomic disadvantage (i.e. the trajectories were parallel). None of the indicators of neighborhood social disorganization were significant predictors of the girls' trajectories of physical aggression when controlling for neighborhood socioeconomic disadvantage. None of the neighborhood risk factors were associated with physical aggression trajectories for boys or with social aggression trajectories for either boys or girls.

Direct Effects of Neighborhood Risk Factors

In addition to the main effects included in the reduced conditional models described above, I further examined the relationship between the neighborhood risk factors and the

outcomes using bivariate correlations and a series of growth curve models each containing only one neighborhood variable to determine whether the effects of these two dimensions of neighborhood risk on the aggression trajectories were confounded. Bivariate correlations (Table 4) indicated that each of the neighborhood characteristics was significantly associated with physical aggression for both boys and girls in the direction expected: Neighborhood socioeconomic disadvantage and neighborhood crime were positively associated with physical aggression, and neighborhood social bonds and social control were negatively associated with physical aggression. None of the neighborhood characteristics were statistically significant correlates of social aggression for either boys or girls.

In the individual main effects models (Table 7), there were no statistically significant interactions of the neighborhood variables with either age or age-squared, so all of the statistically significant effects indicate an influence on the intercept (initial levels of aggression at age 11). There was some evidence suggesting confounding of the effects of neighborhood socioeconomic disadvantage and neighborhood social disorganization on the aggression trajectories. The individual main effects models indicate that, for girls, both neighborhood socioeconomic disadvantage and neighborhood crime reached significance in the individual main effects models predicting physical aggression trajectories. Neither neighborhood social control nor neighborhood social bonding were statistically significant in the individual main effects models predicting trajectories of physical aggression for girls. For boys, neighborhood socioeconomic disadvantage ($p = .08$), neighborhood crime ($p = .08$) and neighborhood social bonding ($p = .10$) approached significance in the individual main effects models predicting physical aggression trajectories. Neighborhood social control was not a significant predictor of trajectories of physical aggression for boys ($p > .10$). None of the neighborhood variables approached significance for either girls or boys in the individual main effects models predicting trajectories of social aggression (all $p > .10$).

Discussion

This study used multilevel growth curve models to document the influence of neighborhood socioeconomic disadvantage and social disorganization (including measures of social bonds between adults, social control, and crime) on trajectories of physical and social aggression during adolescence. The unconditional models showed that perpetration of physical and social aggression followed curvilinear trajectories from ages 11 to 18 for both boys and girls, with the highest levels of aggression between ages 13 and 15. In the conditional models, there were no significant interactions between neighborhood socioeconomic disadvantage and social disorganization for either boys or girls for either outcome. There were significant main effects of neighborhood risk factors, and there was some evidence of confounding of the effects of neighborhood socioeconomic disadvantage and neighborhood social disorganization for both boys and girls when predicting physical aggression.

No previously identified studies have investigated the influence of neighborhood risk factors on social aggression trajectories, which was an important aspect of this study. I did not detect any impact of the neighborhood risk factors on trajectories of social aggression for either boys or girls—not even in bivariate correlations or individual main effects models. There was additional evidence of the limited impact of neighborhood context for social aggression, in that the intraclass correlation coefficient (ICC) for physical aggression at age 11 for girls equated with a medium to large effect size (Duncan & Raudenbush, 2001), which was similar to that seen in other studies (Cook et al., 2002), but the ICC for social aggression at age 11 for girls equated with a small effect size (Duncan & Raudenbush, 2001), with no clustering of social aggression for boys at the neighborhood level at all.

There was no support for the hypotheses regarding the effect of interactions between neighborhood socioeconomic disadvantage and neighborhood social disorganization on the initial levels of aggression, rates of change over time or peak ages of involvement in physical

or social aggression for either boys or girls. This may be due to the localized sample, since neighborhood effects have been found most consistently in studies that include national samples, rather than city-based or regional studies (Leventhal & Brooks-Gunn, 2000). However, I used strong measures of the neighborhood context that included both self-report data on neighborhood social disorganization and administrative data from the U.S. Census about the socioeconomic context. Additionally, the school-based survey was a census of all adolescents enrolled in the public schools in three counties, and there were a wide variety of neighborhoods represented that differed in income levels, racial characteristics and social processes. There also were enough respondents in each neighborhood to enable us to use multilevel analysis techniques to estimate the neighborhood effects (Diez Roux, 2001, 2002; Leventhal & Brooks-Gunn, 2000).

Another potential reason the interaction hypotheses were not supported is suggested by theories of neighborhood effects. Neighborhood social disorganization typically has been proposed to be a mediator of the effect of neighborhood socioeconomic disadvantage on crime, violence and related youth outcomes (Leventhal & Brooks-Gunn, 2000; Sampson, 2001; Sampson et al., 1997). However, I found no evidence of mediation of the effect of neighborhood socioeconomic disadvantage by social disorganization, since the variable that remained statistically significant in the final model was socioeconomic disadvantage, rather than one or more of the indicators of social disorganization. Perhaps the mediational processes proposed by Sampson and colleagues (1997) are more appropriate for other outcomes such as violent crime, or when applied to the behavior of adults or residents of large urban centers, such as Chicago or Pittsburgh.

This study makes several important contributions to the literature about the development of aggression during adolescence. First, I ascertained that the average trajectory for both physical and social aggression was curvilinear for both boys and girls in this predominantly rural sample, conforming to the adolescence-limited pattern suggested

by Moffitt (1993). The results for physical aggression are similar to those found in other trajectory studies involving youth from urban, suburban and rural areas (Farrell & Sullivan, 2004; Farrell et al., 2005; Sampson et al., 2005), and those for social aggression add to data from longitudinal studies that have found that social aggression increases during adolescence (Cairns et al., 1989; Xie et al., 2005). Documenting that the trajectories of social aggression increase and then decline during adolescence is an important addition to research on the development of antisocial behavior, since there have been few longitudinal studies of social aggression during adolescence and none have examined behavioral trajectories.

Second, I established that there is a strong relationship between neighborhood socioeconomic disadvantage and initial levels of physical aggression perpetrated by girls, but that disadvantage did not impact the shape of the girls' trajectories. Other longitudinal studies also have found that the neighborhood socioeconomic environment affects age of onset of violence, with early onset more likely in disadvantaged neighborhoods (Loeber & Hay, 1997; Molnar et al., 2005). Although other researchers have examined the impact of neighborhood risk factors on average levels of violence over time (Sampson et al., 2005), ours is the first study to explicitly investigate the impact of neighborhood socioeconomic disadvantage and social disorganization on rates of change and peak ages of involvement in physical aggression during adolescence. Contrary to some interpretations of Moffitt's (1993) developmental taxonomy of adolescent antisocial behavior (Howell & Hawkins, 1998), I did not find evidence that neighborhood socioeconomic disadvantage or social disorganization were associated with high-risk, life-course persistent trajectories, which are characterized by high levels of aggression over time (very late peak ages and minor declines in perpetration during adolescence). Instead, girls' trajectories of physical aggression showed elevated levels of aggression in more socioeconomically disadvantaged neighborhoods, but their trajectories

still followed the adolescence-limited quadratic shape, with declines in aggression at the same age as their peers in high socioeconomic status neighborhoods.

It is interesting to note the lack of statistically significant effects of the neighborhood risk factors on boys' physical aggression trajectories and the lack of clustering effects at the neighborhood level for boys. Many studies have established links between neighborhood socioeconomic disadvantage and aggression perpetrated by boys (Aneshensel & Sucoff, 1996; Bellair, Roscigno, & McNulty, 2003; Ingoldsby & Shaw, 2002; Leventhal & Brooks-Gunn, 2000). However, few studies have examined the role neighborhoods play in the development of adolescent aggression in nonmetropolitan areas (Ingoldsby & Shaw, 2002). Although the impact of neighborhood socioeconomic disadvantage for girls in this predominantly rural sample was similar to that seen in urban areas, perhaps the socioeconomic context in nonmetropolitan environments has a limited impact on the behavior of adolescent boys. Some researchers have documented an inconsistent relationship between county-level poverty and unemployment and juvenile violent crime arrest rates in rural and nonmetropolitan areas (Osgood & Chambers, 2000), which is additional evidence that neighborhood differences in urban and rural areas deserve further study.

The relationships between the dimensions of social disorganization and the aggression trajectories were very weak. As with neighborhood socioeconomic disadvantage, ecological studies of crime and violence show strong support for social disorganization theories (Pratt & Cullen, 2005), and longitudinal studies using urban samples have shown that neighborhood social disorganization increases the likelihood that adolescents will exhibit an aggression trajectory that shows early onset and increases in aggression over time (Farrington, 1998; Howell & Hawkins, 1998). It is possible that neighborhood social processes are not as strongly related to youth outcomes in predominantly rural environments where the residents may be geographically distant from one another.

However, since I used aggregated data from parent reports of neighborhood social disorganization, additional studies are needed determine whether youth perceptions of neighborhood social processes are more relevant predictors of adolescent outcomes than parents' reports of the same processes.

Finally, I determined that there was little clustering of social aggression for girls or boys at the neighborhood level, and none of the neighborhood risk factors were associated with the social aggression trajectories. Social aggression is difficult to measure well among adolescents (Archer & Coyne, 2005), and it is possible that the items that I used did not adequately capture the essence of this type of aggressive behavior. However, the reliability of the measure was acceptably high and the relationships between social aggression and other risk and protective factors, such as family conflict, parental control and parent-child bonding, are in the direction that would be expected based on previous research (data not shown). Social aggression often involves accomplices in the aggressive acts (Xie et al., 2005) and it typically occurs within social networks (Archer & Coyne, 2005), which suggests that a context with multiple actors or one that contains intact social groups, such as a school setting, may be particularly conducive to such behavior. Thus, contextual factors at the school level may be more strongly related to social aggression than neighborhood factors. Comparative studies examining the relative influence of different domains (such as the school context or peer relationships) may help to illuminate important predictors of social aggression trajectories during adolescence.

This study has several strengths that encourage confidence in the results. First, a large sample of adolescents completed five waves of questionnaires across three different counties. The response rates for the in-school surveys were high, and the adolescent sample was demographically diverse. I used both U.S. Census data and self-report data from a random sample of parents to describe the neighborhood context to avoid same-source bias (Leventhal & Brooks-Gunn, 2000; Raudenbush & Sampson, 1999), and the neighborhood

self-report measures were adjusted for biases associated with the demographic characteristics of the parent respondents (Raudenbush, 2003; Raudenbush & Sampson, 1999) to limit the influence of compositional factors on the estimation of the neighborhood effects (Oakes, 2004). The response rate for the parent interviews, the geocoding success rate and accuracy, and the reliability of the neighborhood measures also were very high. I also imputed missing data using multiple imputation procedures that used many established predictors of physical and social aggression to replace missing values to minimize the effect of attrition in this longitudinal study.

The study does have limitations that deserve mention. Using a predominantly rural sample from a localized area may have impacted the findings (Leventhal & Brooks-Gunn, 2000), and the generalizability of the results may be limited to similar contexts, particularly those with large populations of African-Americans or with lower median incomes than the national levels. However, I found levels of physical and social aggression that were similar to those documented in other studies with youth of similar ages (Farrell et al., 2000), and studying neighborhood effects in a nonmetropolitan context is an important contribution to the literature on adolescent development.

My future research considers multiple contexts of adolescent behavior to discern how neighborhood effects are moderated or mediated by other factors. Research on neighborhood effects in nonmetropolitan areas would benefit from investigation of different social factors such as norms or attitudes about deviant behaviors (Sampson et al., 2005) in the neighborhood environment that may impact youth outcomes. Additional research into the definition of neighborhoods in nonmetropolitan areas may help to establish boundaries of communities that reflect young people's experiences and social interactions (Sampson et al., 2002). Extension of these studies to include impacts of neighborhood factors on the development of aggression over time also would be valuable for promoting healthy development of youth in both advantaged and disadvantaged neighborhood contexts.

PAPER 3: NEIGHBORHOOD AND FAMILY EFFECTS ON PHYSICAL AND SOCIAL AGGRESSION TRAJECTORIES DURING ADOLESCENCE: AN EXPLORATION OF CROSS-LEVEL INTERACTIONS

Abstract

Purpose: To determine whether family factors moderate the relationship between neighborhood risk and physical and social aggression trajectories of male and female adolescents.

Methods: Five waves of data on youth aggression were collected through in-school surveys over 2.5 years. Data from the 2000 U.S. Census and from a random sample of parents were linked to each adolescent's Wave 1 U.S. Census block group to characterize the neighborhood context, and student data from Wave 1 were used to describe family risk and protective factors. The sample (N=5118) was 50.1% female, 52.0% white and 38.3% African-American. The average age at Wave 1 was 13.1 years. Missing data were replaced using multiple imputation procedures, and the average trajectories of physical and social aggression were described using multilevel growth curve models.

Results: For both males and females, the average trajectories for physical and social aggression from ages 11 to 18 were curvilinear, with increases in each type of aggression followed by declines. Counter to the hypotheses, there were no significant interactions between neighborhood risk and the family factors. There were no neighborhood effects on changes in physical or social aggression during adolescence, but family conflict influenced both the initial levels and the linear change in the girls' physical aggression trajectories and in the social aggression trajectories for both boys and girls. Additionally, for boys, less

parental control was associated with higher levels of physical aggression at age 11, and less parent-child bonding and less parental control were associated with higher levels of social aggression at age 11. For girls, more neighborhood socioeconomic disadvantage, less parent-child bonding and less parental control were associated with higher levels of physical aggression at age 11, and less parent-child bonding also was associated with higher levels of social aggression at age 11.

Conclusions: Early prevention programs are needed, and family-centered programs may help prevent both physical and social aggression during adolescence, regardless of the neighborhood context. Neighborhood-level interventions also may help prevent physical aggression perpetrated by girls.

Keywords: adolescent, aggression, trajectory, neighborhood, family, latent growth curve, multilevel model

Introduction

Studies of the impact of neighborhoods on adolescent health risk behaviors such as sexual activity (Brewster, 1994; Upchurch et al., 1999), school dropout (Crowder & South, 2003), substance use (Chuang et al., 2005) and aggression (Farrington, 1998; Ingoldsby & Shaw, 2002; Jencks & Mayer, 1990; Kramer, 2000; Leventhal & Brooks-Gunn, 2000; Sorenson & Berk, 2001; Tatum, 2000; U.S. Department of Health and Human Services, 2001) provide mixed support for the premise that the neighborhood environment influences the behavior of adolescents. Some studies show significant neighborhood effects and others suggest no effect of the neighborhood context on youth outcomes (see review by Leventhal & Brooks-Gunn, 2000, for examples). These inconsistent findings could be due to moderation of the relationship between neighborhood factors and youth behavior by variables not considered in the analysis. However, few studies have examined moderators of the relationship between the neighborhood context and adolescent behavioral outcomes to

describe the circumstances under which neighborhood risk factors impact youth development.

In this study, I investigate whether family factors moderate the relationship between neighborhood risk and trajectories of physical and social aggression for youth in nonmetropolitan areas. The focus on nonmetropolitan areas contrasts with the majority of studies of neighborhood effects, which primarily have been conducted in urban settings. The neighborhood characteristics examined are socioeconomic disadvantage and social disorganization; the family factors are conflict, parent-child bonding and parental control. I assess moderation effects on both physical and social aggression, and I assess effects on the initial level and rates of change of each behavior, as well as on the peak age of involvement, which also is the point at which desistance begins. Additionally, I examine the moderation effects separately for males and females, since I expect sex differences in perpetration (Archer & Coyne, 2005; Cairns et al., 1989; Fergusson & Horwood, 2002; Loeber & Hay, 1997; Xie, Cairns et al., 2002) and developmental trajectories (Magnusson & Stattin, 1998), and the impact of neighborhood and family factors on developmental trajectories during adolescence may be different for boys and girls (Landsheer & van Dijkum, 2005; Leventhal & Brooks-Gunn, 2000, 2003).

Physical and Social Aggression

Physical aggression includes overt behaviors that threaten or cause physical harm to other people (Loeber & Hay, 1997), whereas social aggression encompasses more covert forms of non-physical aggression that are focused on damaging social relationships rather than inflicting or threatening physical harm (Archer & Coyne, 2005). These distinct behaviors have different relationships with risk factors and psychosocial variables (Crick & Grotpeter, 1995; Xie, Swift et al., 2002), as well as with consequences (positive and negative) for perpetrators and victims (Lagerspetz et al., 1988). With few exceptions, the average

longitudinal trajectories of physical aggression (Aber et al., 2003; Farrell et al., 2005) and violence (Sampson et al., 2005) demonstrate a curvilinear pattern that shows an initial increase in activity in early adolescence and a decline later in adolescence. This average pattern resembles the adolescence-limited trajectory described in Moffitt's (1993) developmental typology of antisocial behavior, as opposed to the more problematic life-course persistent trajectory, which is characterized by high levels of antisocial behavior over time, with very late peak ages and minimal declines in perpetration during adolescence.

Neighborhood Risk Factors

Neighborhoods are complex physical and social environments that provide basic infrastructure and opportunities for education and socialization of young residents. Theories of social exclusion and relative deprivation emphasize the role of neighborhood socioeconomic disadvantage in adolescent development (Jencks & Mayer, 1990; Kramer, 2000). Neighborhood socioeconomic disadvantage can impact youth indirectly, by affecting social relationships or social norms (Jencks & Mayer, 1990; Kramer, 2000; Wilson, 1987), or directly through stress and chronic strain (Fitzpatrick & LaGory, 2000). In addition to socioeconomic factors, collective socialization models (Sampson et al., 2002; Wilcox, 2003) and theories of neighborhood social control (Kramer, 2000) emphasize factors such as social disorganization that encompass the social processes in neighborhoods that can promote deviant adolescent behavior such as aggression. In socially disorganized neighborhoods with weak social bonds and low levels of social control, crime and violence are more common than in socially cohesive and organized neighborhoods (Ross & Jang, 2000; Sampson et al., 1997).

These theoretical processes suggest that it is more likely that adolescents will engage in risk behaviors in disadvantaged or disorganized areas than in neighborhoods that are not at risk (Aneshensel & Sucoff, 1996; Bellair et al., 2003; Leventhal & Brooks-Gunn, 2000), and

longitudinal studies show that an early age of onset of violence (Farrington, 1998; Loeber & Hay, 1997) and increases in physical aggression during adolescence (Farrington, 1998; Howell & Hawkins, 1998) are more likely in high-risk neighborhoods. Although few studies have examined the influence of neighborhood factors on trajectories of adolescent aggression (Benson, 2002), studies using other analysis procedures such as growth mixture modeling (Nagin, 1999) suggest that neighborhood risk factors can influence individual trajectories of delinquency and antisocial behavior, with neighborhood socioeconomic disadvantage (Howell & Hawkins, 1998) and neighborhood social disorganization (Chung, Hill et al., 2002) predicting membership in Moffitt's (1993) most problematic life-course persistent trajectory groups.

Family Risk Factors

In addition to neighborhood influences on adolescents, aspects of the general family environment, the parent-child relationship and specific parenting practices contribute to youth development (Caspe, 2004/2005). According to social learning theory, adolescents discover the consequences and benefits of aggressive behavior in part by watching salient referents such as parents and siblings (Baranowski et al., 2002; Mazur, 1990). As such, a family environment characterized by high levels of conflict may promote aggression as a solution to problems. Social control theory (Hirschi, 1969) complements social learning by emphasizing attachment to parents (or to other conventional persons) as a key deterrent to involvement in crime and delinquency. Closeness or attachment to parents may promote conformity to traditional (or non-deviant) values and may facilitate the process of socialization by parents to prevent aggressive and antisocial behaviors (Hirschi, 1994). Similarly, theories of effective parenting (Baumrind, 1991; Darling & Steinberg, 1993) emphasize that both the parent-child relationship and specific parenting practices, such as parental control and supervision, positively affect socialization of youth.

Research indicates that the presence of violence in the home, parent-child bonding and parental control are important determinants of youth aggression (Jackson & Foshee, 1998; Jackson, Henriksen, & Foshee, 1998; Leventhal & Brooks-Gunn, 2000; Paschall, Flewelling, & Ennett, 1998), and longitudinal studies have documented that low levels of parental bonding are related to an early age of initiation of delinquency (Wiesner & Silbereisen, 2003) and to increases in aggression (Dodge, Pettit, & Bates, 1994; Jackson & Foshee, 1998; Saner & Ellickson, 1996) and delinquency (Johnson, Hoffmann, Su, & Gerstein, 1997; Loeber & Stouthamer-Loeber, 1986) over time. Family conflict (Chung, Hawkins, Gilchrist, Hill, & Nagin, 2002; Fergusson & Horwood, 2002), low family emotional support and bonding (Wiesner & Silbereisen, 2003; Wiesner & Windle, 2004), and low parental control (Wiesner & Capaldi, 2003; Wiesner & Silbereisen, 2003) also have been shown to predict membership in life-course persistent trajectory groups.

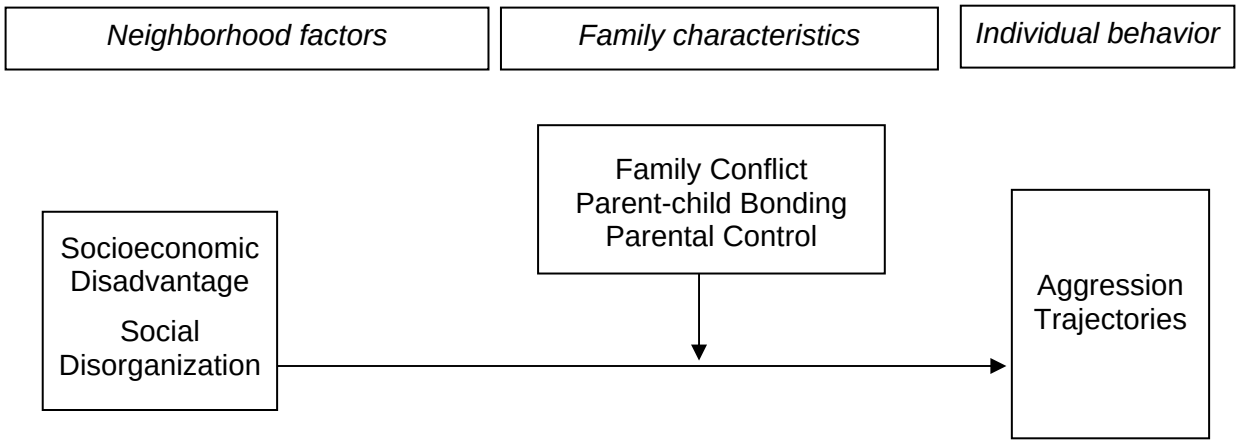
Moderation of Neighborhood Risk by Family Factors

Family factors primarily have been studied as mediators of the influence of the neighborhood environment on children and adolescents (see, for example, Brody et al., 2001), but many researchers have described family influences as potential moderators of neighborhood effects on youth (Cook, 2003; Duncan et al., 1997; Garmezy, 1993; Ingoldsby & Shaw, 2002; Leventhal & Brooks-Gunn, 2000; Spencer, 2001; Spencer, Cole, Jones, & Swanson, 1997). Some family factors may exacerbate the influence of neighborhood risk on youth, while other family factors may buffer the influence of neighborhood risk. For example, Howell and Hawkins (1998) suggested that the effects of neighborhood socioeconomic disadvantage and social disorganization on adolescents may be exacerbated by family risk factors such as family conflict, and that conditions of both family and neighborhood risk may increase the likelihood that an adolescent will follow a life-course persistent trajectory of antisocial behavior.

Another way in which family factors may interact with neighborhood risk factors is by buffering the negative impact of the neighborhood environment. For example, living in a socioeconomically disadvantaged or socially disorganized neighborhood can cause stress from chronic strain, which may be buffered by psychological or social resources, including strong parent-child bonds (Fitzpatrick & LaGory, 2000). Qualitative studies suggest that, for African American boys, neighborhood risk is less damaging for boys from families that have close bonds between adults and children than for boys from families with weaker parent-child bonds (Spencer, 2001), and the results from some quantitative studies also suggest that the negative impact of neighborhood violence on child competence (Krenichyn, Saegert, & Evans, 2001) or adolescent mental health (Ozer, 2005) may be lessened by a supportive family context. Additionally, researchers have speculated that parents may be able to protect their children from a harmful neighborhood context by enacting strict behavioral controls and monitoring their children's exposure to neighborhood risk (Burton & Jarrett, 2000; Leventhal & Brooks-Gunn, 2000).

Although many researchers have hypothesized that the effects of the neighborhood environment on antisocial behaviors perpetrated by youth may be exacerbated or buffered by family processes, only a few have examined such interaction effects empirically. In one large, national study, Hoffman (2002) documented that delinquency was highest among youth living in neighborhoods with high male joblessness and who had low levels of parental supervision. Similarly, Rankin and Quane (2002) found that African-American youth living in neighborhoods with low levels of collective efficacy showed the highest levels of problem behaviors (including delinquency, arrests and drug use) when their parents engaged in low levels of monitoring and control. However, the impact of family and neighborhood moderation effects on physical and social aggression has not been examined.

Figure 4. Neighborhood-family moderation model



Hypotheses

The primary aim of this study is to determine whether family factors moderate the relationship between neighborhood risk and physical and social aggression trajectories during adolescence. The conceptual model is presented in Figure 4. I hypothesize that (1) high levels of family conflict will exacerbate the negative influence of neighborhood socioeconomic disadvantage or social disorganization on youth development and (2) high levels of parent-child bonding and parental control will buffer the influence of negative neighborhood environments on the trajectories. Specifically, I hypothesize that the interaction between neighborhood and family factors will affect the intercept, rates of change and peak age of involvement in aggression, with higher intercepts, faster rates of change and later peak ages of involvement (which indicate delays in desistance) indicating problematic aggressive behavior during adolescence (Moffitt, 1993; Nagin, 1999; Nagin & Tremblay, 2001). The most problematic trajectories (high intercepts, fast rates of change and late peak ages) are expected for youth living in high-risk neighborhoods (high socioeconomic disadvantage, high social disorganization) who also have high-risk family environments (high family conflict, low parent-child bonding, low parental control). I use

multilevel growth curve analysis to test the study hypotheses. I do not make separate hypotheses for boys and girls because there is not enough evidence to support such distinctions, but I do use stratified data to examine sex differences in the nature of the neighborhood and family influences on aggression trajectories.

Methods

Study Design

The data come from the longitudinal Context of Adolescent Substance Use Study, which was designed to investigate contextual influences on adolescent substance use and aggression, with a focus on peer networks, family characteristics and neighborhood factors (Ennett et al., 2006). The study included adolescents from the public schools in three counties in North Carolina. The counties are classified as nonmetropolitan areas with access to an interstate highway, and they also are eligible for targeted federal funds for health services due to their rural location (Ricketts et al., 1999). These counties have greater proportions of African-Americans (M = 27.8%) than does the general United States population (12.2%), and the median household income (M = $36,600) and median housing value (M = $89,400) are lower than the national medians ($42,000 and $111,800, respectively) (U.S. Census Bureau, 2002).

The Context of Adolescent Substance Use Study consists of three components: (1) in-school surveys with adolescents (county-wide census), (2) telephone interviews with a randomly sampled cohort of parents, and (3) linking U.S. Census data with geocoded addresses. Eligible students completed fives waves of questionnaires in the schools (average response rate: 81.1%), and parents participated in three sets of telephone interviews (average response rate: 78.0%). Addresses from students who completed questionnaires and from parents who completed interviews were geocoded at each wave (average success rate: 87.6%). This analysis includes youth-report data on aggression and family characteristics, as

well as parent-report data on the neighborhood context and U.S. Census data linked to the students' block group geocodes. The Public Health Institutional Review Board at The University of North Carolina at Chapel Hill approved all study protocols.

In-School Surveys

Five waves of data were collected from adolescents in schools every 6 months between spring 2002 and spring 2004, beginning when the students were in sixth, seventh or eighth grade and ending when they were in eighth, ninth or tenth grade. At each wave, all adolescents in the public schools in the three study counties were eligible for participation (approximately 6,100 students each wave) except those who could not complete the questionnaire in English (approximately 13 students each wave) and those who were in special education programs in self-contained classrooms (approximately 300 students each wave). At each wave, new students who met the inclusion criteria entered the study.

Parents were notified about the study and had the opportunity to refuse consent for their child's participation at the beginning of each academic year or whenever the child was first enrolled in school. At each wave, trained research assistants administered questionnaires on at least two different occasions at each school to allow those students who had been absent on the primary day of data collection to participate in the study on the make-up day. To ensure classroom order while maintaining confidentiality, teachers remained at their desks while the students completed their questionnaires, and the students placed their questionnaires in envelopes before returning them to the data collectors.

Parent Interviews

A random sample of parents of adolescents who were eligible for Wave 1 in-school data collection was selected to complete telephone interviews. A parent was eligible if the child had completed a Wave 1 questionnaire, if they had only one child in the school-based study and if they could complete the interview in English (N=2062). At Wave 1, 80.7% of the

eligible parents (N=1663) completed interviews during the spring and summer of 2002. Trained data collectors first attempted to reach each adolescent's mother or an adult female living with the adolescent. When no mother figure could be identified, the father or an adult male living with the adolescent completed the interview. Interviews lasted approximately 25 minutes, and the participating parents received a $10 incentive check by mail.

Address Geocoding

Neighborhoods are defined by U.S. Census block group boundaries, since studies have found that U.S. Census block groups can adequately represent neighborhoods and delineate different social and structural factors between different neighborhoods (Cook et al., 1997; Krieger et al., 2002). Student and parent addresses were sent to a commercial geocoding firm to be matched with U.S. Census tracts and block groups. The geocode matches varied in precision from the most precise street matches to the least precise 5-digit ZIP centroid matches. Addresses that were not matched at the street level were cleaned and checked using the U.S. Postal Service website (U.S. Postal Service, n.d.) and a general address mapping website (MapQuest, n.d.), and then a second attempt was made to geocode them using either ArcGIS software (ESRI, 2005) or the U.S. Census American FactFinder website (U.S. Census Bureau, n.d.). The final geocode for each address was assigned based on the results of all geocoding attempts such that street matches were preferred over ZIP centroid matches.

As recommended by Krieger and colleagues (2001), an accuracy study was conducted to evaluate the geocodes returned by the commercial firm and those generated using the ArcGIS software. The accuracy study consisted of a random sample of street matches, stratified by county, generated using a SAS survey selection program (SAS Institute, 2003). The sample of addresses was re-geocoded using the American FactFinder website, which represented the gold standard (Krieger et al., 2001). Overall, 90.4% of the addresses checked

for accuracy matched the gold standard perfectly and an additional 4.3% matched at the tract level but not at the block group level.

Analysis Sample

The analysis sample (N=5118) includes those adolescents who completed a Wave 1 questionnaire, except for those who were younger than 11 or older than 16.5 at Wave 1 (n=26), those who did not give their birth date or sex on any of the questionnaires (n=8), those without a Wave 1 block group geocode (n=35), and those who were the only respondent from their Wave 1 block group (n=33). The age restriction was imposed to limit the number of students who were out of the typical age range for their grade. I limited the analyses to block groups containing more than one student to increase the stability of the neighborhood estimates.

Overall response rates for the analysis sample ranged from 86.6% at Wave 2 to 79.5% at Wave 5. Of the students in the sample, 56.0% participated in the study at all five waves, 15.6% participated in four waves, 15.1% in three waves, 5.3% in two waves only and 8.0% only at Wave 1. Procedures for imputing missing data are described below.

At Wave 1, the majority of students (95.6%) were between the ages of 11 and 14 (M=13.1 years). Half (50.1%) of the students were females, 52.0% were white, 38.3% were black or African-American, 3.8% were Hispanic or Latino, and 5.9% were another race or ethnicity. Most students (80.0%) indicated that they lived with two parents (biological or step-parents), and 73.0% reported that at least one parent had attended college, community college or technical school. At Wave 1, approximately half of the students had perpetrated physical aggression (45.6% of girls and 51.8% of boys) and more than two-thirds had perpetrated social aggression (71.0% of girls and 68.3% of boys).

The student geocodes represented each of the 113 block groups in the three-county area. A small group (1.2%) had geocodes from counties outside the target area, resulting in a total

sample of 128 block groups. There were between 2 and 63 students in each block group. The parent geocodes also represented all of the block groups in the three-county area, with between 2 to 39 parents in each block group, and each of the 128 block groups from the student sample were represented by at least two parent respondents. According to the U.S. Census (2002), the block groups ranged in size from 461 to 3581 people (M=1566, SD=620).

Measures

As described below, both outcomes are modeled as a function of chronological age. To reduce errors associated with birth dates reported incorrectly by younger respondents, age was calculated based on the modal birth date (modal month, modal day and modal year) for all available waves of data, and it was centered by subtracting 11 (the youngest age in the sample at Wave 1) so that the intercepts could be easily interpreted.

Aggression

Physical and social aggression were measured at all five waves. The physical aggression scale (Farrell et al., 2000) assessed how many times in the past three months the respondent had been in a fight in which someone was hit, hit or slapped another kid, threatened to hurt a teacher, and threatened someone with a weapon. Social aggression included the following items: excluded another student from his or her group of friends, spread a false rumor about someone, picked on someone, and started a fight between other people (Farrell et al., 2000). The responses for each item were *none* (0), *1-2 times* (1), *3-5 times* (2), *6-9 times* (3), or *10 or more times* (4). The responses were summed to form a continuous total score for each type of aggression, such that higher scores indicated higher levels of aggression. The Cronbach's alpha ranged from .68 for both the physical aggression scale (M=1.27, SD=2.03) and the social aggression scale (M=2.09, SD=2.48) at Wave 1 to .86 for the physical aggression scale (M=1.36, SD=2.94) and .83 for the social aggression scale (M=2.05,

SD=3.20) at Wave 5. To adjust for skewness, the total aggression scores were log-transformed after adding a constant.

Neighborhood Variables

The neighborhood data came from two sources: the 2000 U.S. Census (U.S. Census Bureau, 2002) and parents' perceptions of their neighborhood (from the Wave 1 telephone interviews). The neighborhood-level covariates are grand-mean centered, so that the intercept and slope terms represent the averages across neighborhoods (Raudenbush & Bryk, 2002; Singer, 1998). Because I used sex-stratified data in the analyses, the grand means were calculated separately for boys and girls.

Neighborhood Socioeconomic Disadvantage. Neighborhood socioeconomic disadvantage encompasses three dimensions: neighborhood education (percentage of people aged 25 and older with less than a high school education), neighborhood employment (percentage of people aged 16 or older in the labor force who were unemployed and the percentage of people aged 16 or older who held working-class or blue-collar jobs) and neighborhood economic resources (percentage of people living below the federally-defined poverty threshold, percentage of households without access to a car, and the percentage of renter-occupied housing units). Working-class or blue-collar jobs included the following: healthcare support; food preparation and serving; building and grounds cleaning and maintenance; personal care and service; sales and office; construction, extraction and maintenance; and production, transportation and material moving occupations (Deane & Shin, 2002; Krieger et al., 2002). The federal poverty threshold was about $17,029 for a family of four in 1999, according to the poverty guidelines updated periodically in the Federal Register by the U.S. Department of Health and Human Services under the authority of 42 U.S.C. 9902(2). The Cronbach's alpha for the six items was .88. A mean score was calculated for each block group (*M*=25.34, *SD*=8.52), and each student was assigned their

block group average. Higher scores indicate higher levels of neighborhood socioeconomic disadvantage.

Neighborhood Social Disorganization. Neighborhood social disorganization was a sum of three composite scores for neighborhood social bonding, neighborhood social control and neighborhood crime, with all three subscales scored so that higher values indicate greater social disorganization. To minimize possible biases associated with the demographic composition of the block groups, I calculated the values for the parent reports of neighborhood social disorganization using a latent variable approach (Raudenbush, 2003). I conducted principle components analyses of the items on each scale, extracted factor scores for each respondent, and used the factor scores in a mixed model framework that accounted for the respondent's demographic characteristics (age, sex, race/ethnicity, level of education, homeowner status and logged length of residence in the home) to determine the level of the neighborhood attribute in each block group (Raudenbush, 2003; Sampson & Raudenbush, 2004). The Cronbach's alpha for the social disorganization measure was .76.

Neighborhood social bonding. Parents responded to four items based on the work of Parker and colleagues (2001) to indicate how often in the past three months they have socialized with one or more neighbors, asked one of their neighbors for help, talked to a neighbor about personal problems, or gone out for a social evening with a neighbor. Responses included *never* (1), *once or twice* (2), *two or three times* (3), or *four or more times* (4). The Cronbach's alpha for this subscale at the individual level was .75 at Wave 1. The scores were reversed in the composite measure of neighborhood social disorganization, so higher scores indicate weak neighborhood social bonds.

Neighborhood social control. Parents responded to six items about the degree of neighborhood social control. They indicated how likely it is that neighbors would step in and do something if teens were damaging property, teens were showing disrespect to an adult, a fight broke out in front of someone's house, teens were hanging out and smoking cigarettes,

teens were hanging out and drinking alcohol, and teens were hanging out and smoking marijuana (Sampson et al., 1997). Responses ranged from *very unlikely* (1) to *very likely* (4). The Cronbach's alpha at the individual level for this subscale was .91 at Wave 1. The scores were reversed in the composite measure of neighborhood social disorganization, so higher scores indicate less effective neighborhood social controls.

Neighborhood crime. Eight items represent neighborhood crime and safety. Parents responded to four dichotomous items about crime in their neighborhood in the three months preceding the interview. The items assessed whether or not they had seen someone get arrested, drug deals, someone being beaten up, or someone pull a gun on another person (*yes* = 1). The parents also indicated how safe they feel walking in their neighborhood during the daytime and after dark (4-point scale, reverse scored, with high scores for *very unsafe* and low scores for *very safe*), as well as the degree to which they agreed or disagreed with the following statements (4-point scale, with high scores for *strongly agree*): "there is too much drug use in my neighborhood" and "there is a lot of crime in my neighborhood". The Cronbach's alpha at the individual level at Wave 1 for this subscale was .79. High scores indicate more crime in the neighborhood.

Family-Level Variables

The family variables include family conflict, parent-child bonding and parental control. The individual-level covariates for the family variables are group-mean centered, so that the intercept and slope terms represent the average intercept and average slope across individuals in each neighborhood (Raudenbush & Bryk, 2002; Singer, 1998). Group-mean centering can reduce problems associated with multicollinearity in models containing cross-level interaction terms (Kreft & De Leeuw, 1998).

Family Conflict. Family conflict consists of responses to three items from Bloom (1985) on the Wave 1 adolescent surveys: "We fight a lot in our family," "Family members

sometimes get so angry they throw things," and "Family members sometimes hit each other." Responses ranged from 0 (*strongly disagree*) to 4 (*strongly agree*), with a middle value of *neither*. The Cronbach's alpha at Wave 1 for these three items was .82. The items were averaged, with high scores indicating higher levels of family conflict (M=0.98, SD=1.15).

Parent-Child Bonding. Parent-child bonding includes 12 items from the adolescent survey at Wave 1. Six items are from the Authoritative Parenting Index (Jackson et al., 1998) and are asked about each parent: "S/he tells me when I do a good job on things," "S/he makes me feel better when I am upset" and "S/he wants to hear about my problems." Responses for these six items ranged from 3 (*just like her/him*) to 0 (*not like her/him*). The other six items also were asked about each parent: how often s/he hugs or kisses you (3 = *a lot*, 0 = *never*), how close you feel toward her/him (3 = *very close*, 0 = *not close at all*), how close do you think s/he feels toward you (3 = *very close*, 0 = *not close at all*). The Cronbach's alpha was .88. The items were averaged, with high scores indicating higher levels of parent-child bonding (M=2.29, SD=0.62).

Parental Control. Three questions from the Authoritative Parenting Index (Jackson et al., 1998) were asked about each parent at Wave 1 to assess parental control and supervision: "S/he has rules that I must follow," "S/he tells me times when I must come home," and "S/he makes sure I don't stay up too late." Responses ranged from 3 (*just like her/him*) to 0 (*not like her/him*), and the Cronbach's alpha was .82. The six items were averaged, with high scores indicating higher levels of parental control (M=2.18, SD=0.78).

Control Variables

The control variables included race/ethnicity, parent education, family structure, the number of times the student moved across the five waves of data collection, the type of address geocoded and the precision of the block group geocode match. I determined values

for the demographic control variables based on all available data across the five waves of surveys. The child's self-reported race or ethnicity was based on the modal response across all waves, and it was represented by three mutually-exclusive dummy variables (black or African-American, Hispanic or Latino, or other race/ethnicity) with white as the reference category. Parent education was measured by the highest level of education attained by either parent, and it included *less than a high school education* (0), *graduated from high school* (1), *some college, community college or technical school* (2), *graduated from community college or technical school* (3), *graduated from college* (4), and *graduate or professional school after college* (5). Family structure was a dichotomous variable indicating residence in a single-parent household at any time during the study (1) compared to continuous residence in a two-parent household (0). A dichotomous variable represented the type of address geocoded at Wave 1 (PO Box = 1; street address = 0). The degree of precision of the Wave 1 geocode match ranged from 5-digit ZIP Code centroid matches (0) to a street-level match (2). The analyses also controlled for the number of times the student moved to a different block group during the five-wave study, with higher numbers representing more moves.

Missing Data

Missing values are common in longitudinal research with adolescents (Faden et al., 2004). To avoid the possible impact of attrition bias in longitudinal studies that use complete-case analysis strategies, missing values were replaced using multiple imputation procedures (Rubin, 1987). First, I specified a missingness equation to guide the imputation. This equation included the dependent variables at all five waves, the independent variables, variables highly correlated with the outcomes from all five waves, variables containing special information about the sample and other variables thought to be associated with missingness (Allison, 2000; Horton & Lipsitz, 2001; Patrician, 2002).

All of the variables included in the imputation were either continuous or dichotomous (Allison, 2005), and I confirmed that the variables were not collinear using eigenanalysis (Belsley et al., 1980) and by examining the variance inflation factors (Neter et al., 1990). I used SAS PROC MI (SAS Institute, 2003) to impute the missing values based on the missingness equation using the Markov Chain Monte Carlo (MCMC) specification (Yuan, 2000). I bounded the imputed values to the valid ranges of the data, and I allowed all imputed dichotomous variables to range between 0 and 1 rather than rounding the values, in accordance with the recommendations of Allison (2005).

The analysis results were combined across the ten imputed datasets using SAS PROC MIANALYZE (Horton & Lipsitz, 2001), which accounts for the uncertainty of the imputation process when calculating summary test statistics, parameter estimates and standard errors. All models had relative efficiencies greater than .95, which suggests that the number of imputations was sufficient to achieve stable estimates (Horton & Lipsitz, 2001).

Analysis Strategy

I used multilevel growth curves to model trajectories for each outcome (physical and social aggression) between ages 11 and 18. The data were stratified by sex and parallel analyses were conducted for each stratum. All analyses were conducted using PROC MIXED in SAS version 9.1 on a SunOS 5.9 platform (SAS Institute, 2003) using a restricted maximum likelihood estimation process and the Kenward-Roger adjustment of the standard errors and degrees of freedom for more conservative tests of the fixed effects (Kenward & Roger, 1997).

Multilevel Models

Random effects models (including multilevel models and latent growth curve analyses) describe trajectories of behavior over time and assess predictors of those behavioral

trajectories (Curran & Willoughby, 2003; Guo & Hipp, 2004; Raudenbush & Bryk, 2002). The multilevel equation can be specified as:

$$\mathbf{Y_{tij} = \pi_{oij} + \pi_{1ij}(AGE)_{tij} + \pi_{2ij}(AGE^2)_{tij} + e_{tij}} \quad \text{for girls: i=1,...,2565; j=1,...128; for boys: i=1,...,2553; j=1,...128} \quad (1)$$

$$\mathbf{\pi_{pij} = \beta_{poj} + \sum_{q=1}^{Q_p} \beta_{pqj} X_{qij} + r_{pij}} \quad p=0, 1, 2 \quad (2)$$

$$\mathbf{\beta_{pqj} = \gamma_{pqo} + \sum_{s=1}^{S_{qp}} \gamma_{pqs} W_{sj} + u_{pqj}} \quad p=0, 1, 2; q=0, 1,...Q_p \quad (3)$$

The level-1 model (1) denotes change over time within individuals. Y_{tij} represents the observed aggression score at age t for child i in neighborhood j, and it is a function of a quadratic curve plus random error (e_{tij}). π_{oij} is the total aggression score of child$_{ij}$ at age 11, π_{1ij} is the linear slope for child$_{ij}$, and π_{2ij} is the quadratic slope for child$_{ij}$.

The level-2 models (2) denote differences between individuals within neighborhoods, and they are used to predict the parameters from the level-1 model. The family factors (family conflict, parent-child bonding and parental control) and the demographic and geocoding control variables (race / ethnicity, parent education, family structure, type of address geocoded, precision of the geocode match and the number of moves) predict the intercept (π_{oij}) from the level-1 model; the family factors and demographic control variables predict the linear slope (π_{1ij}); and the family factors also predict the quadratic slope (π_{2ij}). β_{poj} is the intercept for neighborhood j in modeling the child effect π_{pij}, where X_{qij} is one of the Q_p individual-level variables characteristic of child i in neighborhood j. β_{pqj} represents the effect of X_{qij} on the pth growth parameter, and r_{pij} is the random effect for each child.

The level-3 models (3) denote differences between neighborhoods. The neighborhood-level covariates (W_{sj}) are included at this level, and these models are used to predict the

parameters from the level-2 models. Each β_{pqj} is predicted by the neighborhood-level characteristics, where γ_{pqo} is the intercept in the neighborhood-level model for β_{pqj}, W_{sj} is a neighborhood characteristic used as a predictor for the neighborhood effect on β_{pqj}, γ_{pqs} is the level-3 coefficient that represents the direction and strength of the association between neighborhood characteristic W_{sj} and β_{pqj}, and u_{pqj} is a random effect for each neighborhood. Neighborhood socioeconomic disadvantage and neighborhood social disorganization were specified as predictors of the intercept, linear slope and quadratic slope from the level-2 model in order to produce the cross-level neighborhood-family interaction terms.

The analyses used sex-stratified data, and the models for boys and girls differed slightly, as described below. The preliminary models included four random effects (neighborhood intercept, u_{00j} [$u_{10j} = 0$ and $u_{20j} = 0$]; individual intercept, r_{0ij}; individual linear slope, r_{1ij}; and individual quadratic slope, r_{2ij}), but not all of the random effects were estimable, which suggests that there were more random effects than the data could support given the limited number of time points per subject. For girls, all of the random effects were estimable once the random individual quadratic slope was dropped from the model (i.e. at level 2, $r_{2ij} = 0$). Thus, I included three random effects in the models for girls, and I allowed the level-2 random effects to correlate. After I dropped the random quadratic slope for boys (i.e. at level 2, $r_{2ij} = 0$), additional analyses determined that the neighborhood clustering effect in the boys' data was at or near zero, so at level 3, I also set $u_{00j} = 0$. Thus, I included two random effects in the final models for boys, which were allowed to correlate. At the individual level (level-2), the random effects indicate variability of individual trajectories (the within-person models). At the neighborhood level, the random effects indicate the level of variability across the different neighborhoods in the sample.

Analyses to Test Study Hypotheses

Unconditional Models and Bivariate Statistics. I modeled physical and social aggression as a function of chronological age, including a quadratic term. Unconditional models describe the average physical and social aggression trajectories for boys and girls from age 11 to age 18 without considering covariates. I used joint hypothesis tests of the linear and quadratic slopes (block *F*-tests) to determine whether the trajectories were curvilinear, and I obtained the peak age from the first derivative using a ratio of the regression coefficients ($-B_{age}/2B_{age\text{-}squared}$). A Taylor series approximation (the delta method) was used to obtain the standard error of the estimated peak age (Sen & Singer, 1993). Because the MIANALYZE procedure does not include the covariance parameters from mixed models, I combined the covariance parameters from the unconditional models across the ten imputed datasets using the formulas provided by Rubin and Schafer (1997). I also calculated bivariate correlation coefficients between time-varying values of physical and social aggression and the neighborhood and family variables at Wave 1 using the formulas provided by Rubin and Schafer (1997) to combine the correlation coefficients across the ten imputed datasets.

Moderation Analyses. Conditional models were used to determine whether the family factors moderated the relationship between neighborhood risk and trajectories of physical and social aggression. Significant two-way interactions between the two neighborhood risk factors and the three family constructs indicate an impact on the intercept. Significant three-way interactions between the time variables (age or age-squared), each neighborhood risk variable and each of the three family variables test the moderated effect on the rate of change over time and the peak age of involvement in aggression. Based on preliminary analyses, I included both main effects and interactions of the demographic control variables with age to account for the impact of the demographic characteristics on the intercept and change over time.

All moderators were entered into the model simultaneously, and the variables were evaluated in blocks: (1) age, age-squared, neighborhood variables, family variables, control variables; (2) six 2-way neighborhood-family product terms; (3) ten 2-way interactions involving age or age-squared and the neighborhood and family variables; (4) six 3-way interactions involving age and the neighborhood-family product terms; and (5) six 3-way interactions involving age-squared and the neighborhood-family product terms. The conditional models were simplified using backwards elimination (starting with block 5) to remove any blocks that were not statistically significant. The contribution of each block to the model was assessed using a multivariate *F*-test to limit the overall Type 1 error level to .05 to account for the multiple inferences being made.

Main Effects of Neighborhood and Family Factors on Aggression Trajectories. When there were no significant interactions between the neighborhood risk factors and the family factors, I re-examined the main effects of the neighborhood and family constructs on the intercepts and slopes of the aggression trajectories. I used conditional mixed models that did not include the neighborhood-family interactions (neither the 2-way neighborhood-family product terms nor the 3-way interactions involving age or age-squared and the neighborhood-family product terms) to assess the effect of the two neighborhood risk factors and the three family variables on the trajectories. I included interactions of the neighborhood and family predictors with age and age-squared to detect effects on the rates of change and peak ages of each trajectory. I used backwards elimination to simplify the models by removing nonsignificant blocks of interaction terms, starting with the five 2-way interactions involving age-squared and the neighborhood and family variables, and then considering the block of five 2-way interactions involving age and the neighborhood and family variables. Within each significant block, individual terms were trimmed from the models if they were not statistically significant at the .01 level, as determined by a Bonferroni correction to limit the overall Type I error to .05. The models

included the control variables (main effects and interactions with age), and nonsignificant interactions between the demographic control variables and age were not trimmed from the models. In the case of significant interactions of a neighborhood or family predictor with age or age-squared, the trajectories were graphed for high and low values of the predictor of interest, represented by scores of one standard deviation above and below the mean, respectively, and setting all other predictors to the group average (zero).

Results

Trajectories of Physical and Social Aggression

The joint *F*-tests for the linear and quadratic slopes for physical aggression (F (2, 143.7) = 16.47, $p < .01$, for boys, and F (2, 105.4) = 19.79, $p < .01$, for girls) and social aggression (F (2, 149.7) = 29.53, $p < .01$, for boys, and F (2, 161.5) = 25.92, $p < .01$, for girls) and the direction of the coefficients (significant positive linear slopes and significant negative quadratic slopes) suggest that the trajectories for both physical and social aggression were curvilinear in both samples, with initial increases in aggression followed by declines over time. The peak ages of involvement in physical aggression were age 15.2 for boys (95% confidence interval: 13.4, 16.9) and age 14.6 for girls (95% confidence interval: 13.8, 15.3); for social aggression, the peak ages were age 13.9 for boys (95% confidence interval: 13.1, 14.6) and age 13.7 for girls (95% confidence interval: 13.2, 14.3).

Bivariate Statistics

As shown in Table 8, bivariate correlations indicated that each of the neighborhood and family characteristics was significantly associated with physical aggression for both boys

Table 8. Bivariate correlations between neighborhood and family constructs and aggression outcomes.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) Physical aggression	---	.71**	.05**	.04**	.17**	-.11**	-.10**
(2) Social aggression	.61**	---	-.01	-.01	.11**	-.09**	-.09**
(3) Neighborhood socioeconomic disadvantage	.12**	.02	---	.72**	0.04**	-.12**	-.12**
(4) Neighborhood social disorganization	.09**	.01	.72**	---	0.05**	-.08**	-.08**
(5) Family conflict	.19**	.16**	.08**	.08**	---	-.28**	-.15**
(6) Parent-child bonding	-.14**	-.12**	-.08**	-.08**	-.35**	---	.56**
(7) Parental control	-.14**	-.09**	-.12**	-.08**	-.24**	.52**	---

Note. Males (N=2553) above diagonal; females below (N=2565). * $p < .05$. ** $p < .01$.

Table 9. Neighborhood and family effects on trajectories of physical and social aggression from age 11 to age 18 (reduced models)

	Boys (N=2553)				Girls (N=2565)			
	Physical Aggression		Social aggression		Physical Aggression		Social aggression	
	B	95% CI	B	95% CI	B	95% CI	B	95% CI
Intercept	0.362**	(0.179, 0.545)	0.595**	(0.380, 0.810)	0.283**	(0.119, 0.447)	0.657**	(0.468, 0.846)
Age	0.093**	(0.022, 0.164)	0.157**	(0.079, 0.234)	0.127**	(0.078, 0.177)	0.146**	(0.092, 0.202)
Age-squared	-0.016**	(-0.025, -0.007)	-0.032**	(-0.042, -0.022)	-0.019**	(-0.026, -0.013)	-0.027**	(-0.035, -0.019)
Socioeconomic disadvantage	0.003	(-0.001, 0.007)	0.002	(-0.002, 0.006)	0.007**	(0.003, 0.011)	0.003	(-0.001, 0.007)
Social disorganization	0.022	(-0.031, 0.074)	0.000	(-0.059, 0.060)	-0.018	(-0.075, 0.039)	-0.004	(-0.066, 0.058)
Family conflict	0.107**	(0.087, 0.127)	0.125**	(0.075, 0.176)	0.159**	(0.125, 0.193)	0.134**	(0.094, 0.174)
Parent-child bonding	-0.029	(-0.077, 0.019)	-0.058*	(-0.110, -0.007)	-0.043*	(-0.080, -0.006)	-0.087**	(-0.130, -0.045)
Parental control	-0.067**	(-0.101, -0.033)	-0.072**	(-0.109, -0.036)	-0.051**	(-0.079, -0.023)	-0.025	(-0.059, 0.009)
Age * Family conflict			-0.021**	(-0.036, -0.005)	-0.023**	(-0.034, -0.012)	-0.020**	(-0.033, -0.007)

Note. CI = confidence interval. All analyses controlled for race/ethnicity, parent education, family structure, the number of times the student moved across the five waves of data collection, the type of address geocoded and the precision of the block group geocode match.

* $p < .05$. ** $p < .01$.

and girls in the direction expected: Neighborhood socioeconomic disadvantage, neighborhood social disorganization and family conflict were positively associated with physical aggression, and parent-child bonding and parental control were negatively associated with physical aggression. Neither of the neighborhood characteristics were statistically significant correlates of social aggression for either boys or girls. Family conflict was positively associated with social aggression, and parent-child bonding and parental control were negatively associated with social aggression for both boys and girls.

Moderated Effects

None of the interactions between neighborhood socioeconomic disadvantage or neighborhood social disorganization and family conflict, parental control or parent-child bonding were statistically significant for physical or social aggression for boys or girls. Thus, there was no support for the hypotheses regarding the effect of interactions between neighborhood risk and family factors on the intercepts or linear slopes of the trajectories or on the peak ages of involvement in physical or social aggression.

Main Effects of Neighborhood and Family Risk Factors

Because there were no interactions between the neighborhood and family characteristics, I re-examined the main effects of the neighborhood and family variables using a series of models that included interactions of the neighborhood and family predictors with age and age-squared to detect effects on the initial levels, rates of change and peak ages of the trajectories. Results from the reduced conditional models are presented in Table 9.

When predicting boys' physical aggression trajectories, there were no statistically significant interactions of any of the neighborhood or family variables with either age or age-squared, but more family conflict and less parental control were associated with higher levels of physical aggression at age 11. There was a significant interaction between family conflict and age when predicting boys' trajectories of social aggression (see Figure 5, top

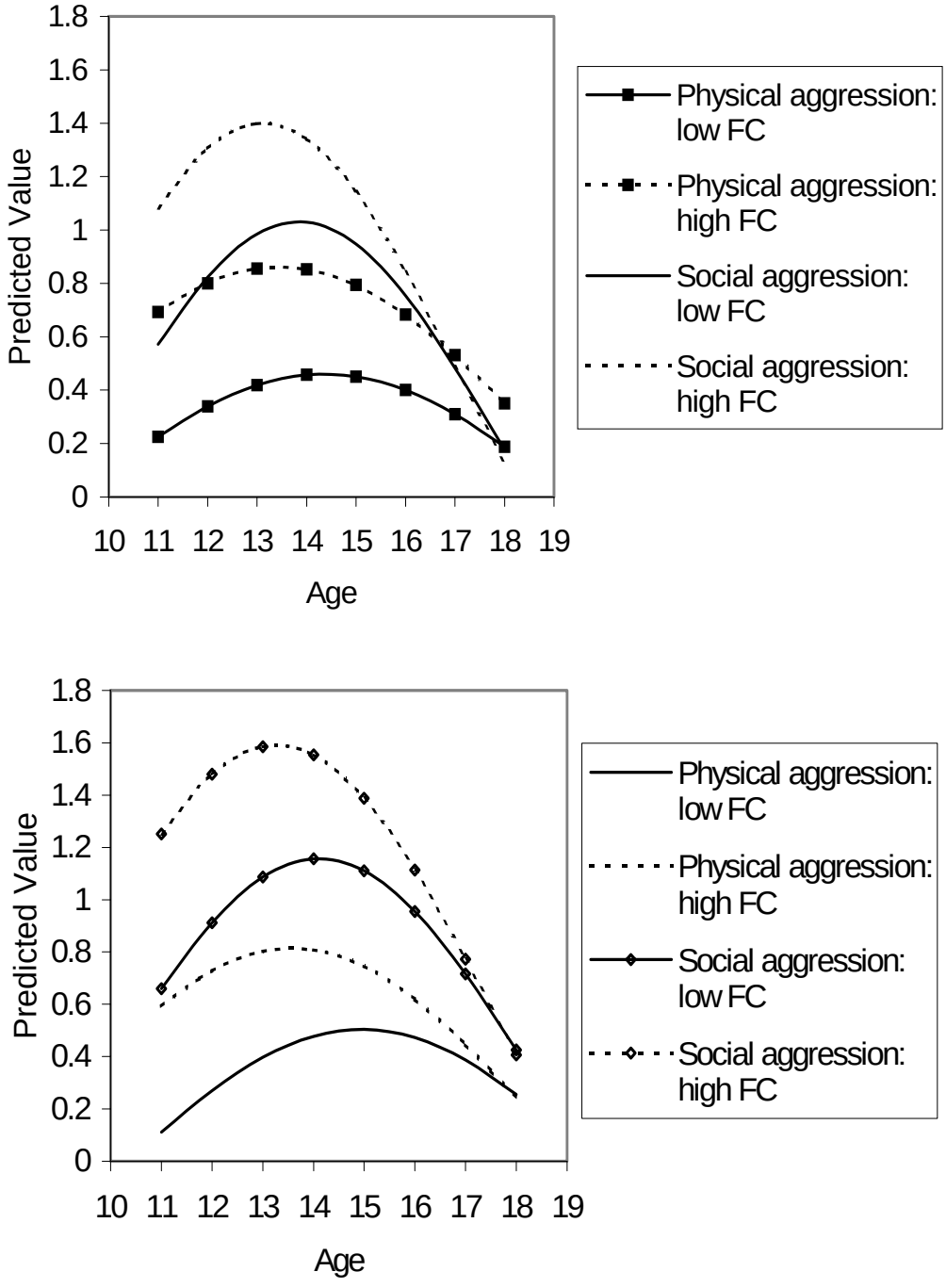
panel). The highest initial levels of social aggression were for boys in high-conflict families, and the peak age of involvement in social aggression was earlier for boys in high-conflict families (13.1 years) than for boys in low-conflict families (13.9 years). Less parent-child bonding and less parental control also were associated with higher levels of social aggression at age 11 for boys.

There was a significant interaction between family conflict and age when predicting girls' trajectories of both physical and social aggression (see Figure 5, bottom panel). The highest initial levels and earliest peak ages of involvement in both types of aggression were for girls from high-conflict families. The peak age of involvement in physical aggression was earlier for girls in high-conflict families (13.6 years) than for girls in low-conflict families (15.0 years). The peak age of involvement in social aggression also was earlier for girls in high-conflict families (13.3 years) than for girls in low-conflict families (14.1 years). Additionally, greater neighborhood socioeconomic disadvantage, less parent-child bonding and less parental control were associated with higher levels of physical aggression perpetrated by girls at age 11, and less parent-child bonding also was associated with higher initial levels of social aggression.

Discussion

I used multilevel growth curve models to examine the moderated and direct effects of neighborhood risk factors (socioeconomic disadvantage and social disorganization) and family factors (family conflict, parent-child bonding, and parental control) on trajectories of physical and social aggression during adolescence. There were no significant interactions between either of the neighborhood risk factors and any of the family factors for either boys or girls for either outcome. However, there were significant main effects of both neighborhood and family factors on the aggression trajectories, including effects on the intercepts and rates of change.

Figure 5. Effect of Age X Family Conflict (FC) interactions on physical and social aggression trajectories for boys (top panel) and girls (bottom panel)



Note. The Age X FC interaction was not statistically significant (p = .06) when predicting physical aggression for boys.

Neighborhood-Family Interactions

I found no support for the hypotheses regarding the effect of interactions between neighborhood risk and family factors on the initial levels of aggression, rates of change over time or peak ages of involvement in physical or social aggression for either boys or girls. Several studies have suggested that family protective factors may be able to buffer negative neighborhood effects on youth (Krenichyn et al., 2001; Rankin & Quane, 2002; Spencer, 2001), but most of these studies have not included empirical examinations of interactions to quantify moderation effects. Rather, they primarily have been studies of parenting behaviors of predominantly poor, African American families residing in poor neighborhoods (Leventhal & Brooks-Gunn, 2000). In contrast, I examined moderation effects in a sample of Caucasian, African American and Latino families from a range of nonmetropolitan neighborhood environments and found no evidence of either buffering or exacerbation of neighborhood effects by family factors. Other researchers also have examined interactions between neighborhood and family factors and found significant direct effects, rather than moderated effects, when predicting misbehavior in a general sample of adolescents (Cook et al., 2002) and when examining correlates of delinquency in a national sample of youth (Hoffman, 2002). For example, Hoffman (2002) found no interactions between neighborhood poverty or the prevalence of female-headed households with family factors such as parent-child bonding and parental control. Thus, a growing body of evidence appears to suggest that the influence of the family context may not vary across neighborhood environments.

Family-Level Main Effects

Family conflict, parent-child bonding and parental control appeared to be more influential determinants of trajectories of physical and social aggression during adolescence than either neighborhood socioeconomic disadvantage or social disorganization. This is

consistent with socioecological models of youth development that emphasize more proximal factors over distal influences (Bronfenbrenner, 1979) and with longitudinal studies of aggression and related behaviors that suggest that an early age of initiation and high levels of offending throughout adolescence are largely caused by family factors (Benson, 2002; Patterson, DeBaryshe, & Ramsey, 1989; Patterson, Forgatch, Yoerger, & Stoolmiller, 1998).

In this study, the family factors had fairly consistent effects on the initial levels of both outcomes for boys and girls. For example, when controlling for the neighborhood risk factors, parent-child bonding was protective for all outcomes except for physical aggression perpetrated by boys, and parental control was protective for all outcomes except for social aggression perpetrated by girls. These findings are similar to those from longitudinal studies that have documented that low levels of parent-child bonding and low levels of parental control are related to an early age of initiation of delinquency (Wiesner & Silbereisen, 2003). However, in contrast to results from other longitudinal studies of aggression (Dodge et al., 1994; Jackson & Foshee, 1998; Saner & Ellickson, 1996) and delinquency (Loeber & Stouthamer-Loeber, 1986; Wiesner & Silbereisen, 2003), I found no influence of either parent-child bonding or parental control on rates of change in aggression over time for either boys or girls. In the trajectory context, this suggests that the effects of these family factors were fairly stable throughout adolescence, in addition to indicating that the trajectories for high- and low- subgroups were the same shape.

Family conflict was the only predictor that influenced both the shapes of the aggression trajectories and the initial levels of aggression. Family conflict was significantly associated with the initial levels of all outcomes and with the rates of change over time for every outcome except for physical aggression perpetrated by boys. According to Moffitt's developmental taxonomy, family risk factors should increase the likelihood that a child will follow a life-course persistent trajectory characterized by high levels of aggression over time (with very late peak ages and minor declines in perpetration during adolescence) (Howell &

Hawkins, 1998; Moffitt, 1993). However, in this study, the mean trajectories for youth from both high- and low-conflict families showed a quadratic shape suggestive of adolescence-limited trajectories (rather than life-course persistent trajectories), and the peak ages of involvement in aggression actually were earlier in high-conflict families than in low-conflict families for both boys and girls. As no other identified studies have examined the influence of family conflict on aggression trajectories in adolescence, additional research is necessary to replicate these findings in different samples of adolescents. Future studies also should investigate the mechanisms by which family conflict influences aggression during adolescence to better understand how social learning impacts initial levels and rates of change of aggression over time. For example, adolescents from low-conflict families may learn physically and socially aggressive behaviors from their more aggressive peers at school or in the neighborhood, rather than from their family members, which might explain why the peak ages of involvement in both types of aggression were later for youth from low-conflict families.

Neighborhood-Level Main Effects

The only significant neighborhood effect was that of socioeconomic disadvantage on initial levels of girls' physical aggression trajectories. Neighborhood disadvantage was not related to rates of change in physical aggression for girls. It also was not related to trajectories of physical aggression perpetrated by boys or to the social aggression trajectories of either girls or boys. Longitudinal studies have found that the neighborhood socioeconomic environment affects age of onset (Loeber & Hay, 1997) and changes in violence over time (Howell & Hawkins, 1998), with early onset and greater increases in aggression and violence more likely in disadvantaged neighborhoods. Although the impact of neighborhood socioeconomic disadvantage on physical aggression perpetrated by girls in this predominantly rural sample was somewhat similar to effects seen in urban areas,

perhaps the neighborhood socioeconomic context has a more limited impact on the behavior of adolescents in nonmetropolitan environments. Few studies have examined the role neighborhoods play in the development of adolescent aggression outside urban areas (Ingoldsby & Shaw, 2002), but the results from the current study indicate that the neighborhood socioeconomic context in nonmetropolitan areas may be most influential early in the development of physical aggression perpetrated by girls.

Neighborhood social disorganization was not related to the physical or social aggression trajectories for either girls or boys. Theories of social disorganization have received very strong support in ecological studies of crime and violence (Pratt & Cullen, 2005), but it is possible that neighborhood social processes are not as strongly related to individual-level youth outcomes in predominantly rural environments where the population density is low and residents may be geographically distant from one another. It also may be that family bonding and control processes take precedence over more remote neighborhood social factors, such as social disorganization (Bronfenbrenner, 1979), particularly in nonmetropolitan settings.

It is interesting that neither of the neighborhood risk factors was significantly related to the trajectories of social aggression for either boys or girls. It is possible that socially aggressive behaviors are more closely linked to the school context, rather than the neighborhood context, given the nature of adolescent social relationships and the peer group orientation of behaviors such as spreading rumors and excluding others from social situations. The strong relationship between the family factors, such as family conflict, and social aggression also suggests that social learning at the more proximal interpersonal level may be a more important determinant of socially aggressive behaviors than neighborhood socioeconomic status or social disorganization (Merrell, Buchanan, & Tran, 2006).

Another possible explanation for the findings from the current study is that family factors may be mediators of neighborhood effects, rather than moderators (Bronfenbrenner,

1979). Some studies have found that neighborhood socioeconomic disadvantage and social disorganization negatively impact parents' ability to be supportive of or to monitor their children (Simons, Johnson, Conger, & Lorenz, 1997), which in turn could lead to negative youth outcomes, such as aggressive behavior. The results from the current study do not suggest full mediation of the effect of neighborhood socioeconomic disadvantage by family factors. In additional analyses examining the impact of disadvantage on physical and social aggression trajectories without accounting for the family context (results not shown), the only statistically significant main effect was a positive association between neighborhood socioeconomic disadvantage and initial levels of physical aggression perpetrated by girls—there was no effect of disadvantage on the boys' physical aggression trajectories or on the social aggression trajectories of either boys or girls. Since the effect of neighborhood socioeconomic disadvantage on initial levels of physical aggression for girls remained statistically significant in the models including the family factors, strong mediation effects were not occurring (Baron & Kenny, 1986). In contrast, the additional analyses examining the impact of neighborhood social disorganization on the aggression trajectories without accounting for levels of socioeconomic disadvantage (results not shown) showed that the influence of social disorganization on the initial levels of physical aggression approached significance for both girls and boys, which suggests that the effects may have been mediated or confounded by neighborhood socioeconomic disadvantage or the family factors (MacKinnon, Krull, & Lockwood, 2000). However, I did not test the significance of any mediated effects (Frazier, Tix, & Barron, 2004; Krull & MacKinnon, 2001), as this was not the primary focus of this investigation.

Strengths and Limitations

This study has several strengths based on the study design, sample, measures and analysis strategy. First, a large census of adolescents from three counties completed five

waves of questionnaires. The response rates for the in-school surveys and for the parent interviews were high, and the geocoding success rate and accuracy were very good. The adolescent sample was demographically diverse, and there were a wide variety of neighborhoods represented that varied by income, racial characteristics and social processes. Furthermore, the indicators of family context were based on established measures of family functioning, and the reliability of the measures was high. The reliability of the neighborhood measures also was very high. I used both U.S. Census data and self-report data from a random sample of parents to describe the neighborhood context to avoid same-source bias (Leventhal & Brooks-Gunn, 2000; Raudenbush & Sampson, 1999). Additionally, the neighborhood self-report measures were adjusted for biases associated with the demographic characteristics of the parent respondents (Raudenbush, 2003; Raudenbush & Sampson, 1999) to limit the influence of compositional factors on the estimation of the neighborhood effects (Oakes, 2004). Finally, there were enough respondents in each neighborhood to enable us to use multilevel analysis techniques to estimate the neighborhood effects (Diez Roux, 2001, 2002; Leventhal & Brooks-Gunn, 2000). I also imputed missing data using multiple imputation procedures that used many established predictors of physical and social aggression to replace missing values, which allowed us to use the data from all students in the analyses and to minimize the effect of attrition in this longitudinal study.

This study also has some limitations that deserve mention. Although examining neighborhood and family effects on aggression in a nonmetropolitan context is an important contribution to the literature on adolescent development, using a predominantly rural sample from a localized area may have impacted the findings regarding neighborhood effects on aggression (Leventhal & Brooks-Gunn, 2000). Additionally, the generalizability of the results may be limited to similar contexts, particularly those with large populations of African-Americans or with lower median incomes than the national levels. Another concern

is that the strength of the family effects may be partly attributable to same-source bias, since the measures of the family factors and the outcome measures were derived from youth-report data. However, I did find levels of physical and social aggression that were similar to those documented in other studies with youth of similar ages (Farrell et al., 2000), and the findings related to family-level predictors of aggression resemble those from other longitudinal studies.

Implications for Prevention

This study has several implications for prevention of youth aggression. Most of the significant family and neighborhood predictors impacted initial levels of aggression, which suggests that early prevention programs are needed to lessen the impact of aggression during adolescence. Family-based programs implemented in childhood may help prevent both physical and social aggression during adolescence (Lacourse et al., 2002), regardless of the neighborhood context in which a family resides. Furthermore, complementary neighborhood-level interventions may help prevent physical aggression perpetrated by girls. When designing interventions for adolescents in nonmetropolitan areas, collective socialization models (Sampson et al., 2002; Wilcox, 2003) and social control theories (Kramer, 2000) about neighborhood effects on youth may not be as useful (particularly when targeting socially aggressive behaviors) as individual-level theories of family processes, such as social control (Hirschi, 1969) and social learning theories (Baranowski et al., 2002) and theories of effective parenting (Baumrind, 1991; Darling & Steinberg, 1993). Further research is needed to understand the most effective ways to promote healthy development of youth in a variety of family and neighborhood contexts.

SUMMARY

This dissertation used multilevel growth curve models to examine the development of physical and social aggression for youth in nonmetropolitan areas, including comparison of the trajectories of different types of aggression and detailed investigation of the relationship between neighborhood risk factors and between neighborhood risk and family factors. The importance of studying multiple levels of influence on adolescent risk behavior was recently emphasized by Cook (2003), who stressed that the influence of neighborhoods, schools, peer groups and families are interrelated, and that thorough studies should include multiple indicators of the aspects of each context under study to disentangle the layered effects on youth. The studies in this dissertation contribute to the existing empirical literature about youth aggression by describing the developmental trajectories and by combining theoretically-derived predictors of aggression in models that test moderation effects at the neighborhood level and between the neighborhood and family contexts to better understand the circumstances under which these contextual factors influence youth aggression.

Boys and girls followed similar aggression trajectories, and there were important direct effects of neighborhood and family factors on the development of physical and social aggression during adolescence, although the relationships between the contextual factors and aggression varied somewhat for boys and girls. Neighborhood socioeconomic disadvantage had the strongest influence on the trajectories of physical aggression perpetrated by girls, and the family factors were more influential determinants of the aggression trajectories than the neighborhood risk factors. This is consistent with socioecological models of youth development that emphasize more proximal factors over distal influences (Bronfenbrenner, 1979), and with an extensive study of multiple contexts by

Cook and colleagues (2002) that also found evidence of cumulative, additive effects across contexts.

Practitioners should include both social and physical aggression in prevention programs for males and females. I found that most of the significant family and neighborhood predictors impacted levels of aggression at age 11, which suggests that early prevention programs are needed to lessen the impact of aggression during adolescence. Family-based programs implemented in childhood may help prevent both physical and social aggression during adolescence (Lacourse et al., 2002), regardless of the neighborhood context in which a family resides. Furthermore, complementary neighborhood-level interventions may help prevent physical aggression perpetrated by girls. The results from this series of studies may help public health researchers, policy makers and practitioners when developing tailored prevention programs and community outreach strategies to lessen the impact of youth aggression across the United States.

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