Taking Stock of Developmental Trajectories of Criminal Activity over the Life Course

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Abstract Worldwide, criminologists have long been interested in the longitudinal patterning of criminal activity. Recently, methodological and statistical advances have "caught up" with longitudinal data and have provided criminologists with a unique window within which to study, document, and understand developmental trajectories of criminal activity. One such technique, the trajectory procedure, allows researchers to study how criminal activity changes over time in a group-based framework. This methodology is well suited for studying crime over the life course because there may be different groups of offenders, their offending trajectories may exhibit different shapes at different ages, and they may be differentially affected by distinct factors. This paper presents an overview of the trajectory methodology, outlines its strengths and weaknesses, and summarizes key conclusions of the well over 80 studies that have used this technique. It concludes by pointing to several future research directions.

Key words: trajectories, crime, life-course, developmental

Introduction

Charting the course of development over long periods of time occupies a central place in the social and behavioral sciences, and criminology is no exception. In particular, the onset, continuation, and cessation of criminal activity has occupied the imagination of criminologists since the beginning of the discipline (Kobner, 1893; Shaw, 1930; von Mayr, 1917; von Scheel, 1890), through its ascendance in the 20th century (Wolfgang, Figlio, & Sellin, 1972), and continues en force today (Blumstein, Cohen, Roth, & Visher, 1986; Piquero, Farrington, & Blumstein, 2003, 2007). With this interest in the natural history of offending, researchers have relied on longitudinal studies which follow individuals for lengthy periods of time. A key part of all longitudinal studies is the repeated measure of a behavior of interest. With the promise of increased knowledge about criminals and their crimes (McCord, 2000:113), longitudinal studies have allowed criminologists to pay close attention to the longitudinal patterning of criminal activity over the life course. For the study

of criminal careers, longitudinal data are necessary as it provides the mechanism by which to study change in offending across the life-course. In fact, longitudinal studies are necessary for making proper inferences about individual trajectories of stability and change (Sampson & Laub, 1993:251) as well as how life events alter trajectories of criminal activity over the life-course (Laub, Nagin, & Sampson, 1998).

There have been many longitudinal studies focusing on criminal activity, in different eras and parts of the world. For example, longitudinal studies exist in the United States, Canada, Puerto Rico, England, Scotland, Denmark, Sweden, Finland, China, Japan, Switzerland, Australia, New Zealand—as well as cities within those countries, and employ a varied array of sampling frames (general population, high risk population, and offenders) (see Weitekamp & Kerner, 1994). This material has generated an impressive and important amount of information about the natural history of criminal offending that would not have been possible through the use of cross-sectional designs that only provide a snap-shot of individuals at one particular point in time.[1] Although there exists several efforts that take stock of the key findings of longitudinal studies (see Thornberry & Krohn, 2003; Weitekamp & Kerner, 1994), it is useful to briefly review several of the findings that are common to the many longitudinal studies.

First, misbehavior starts early in the life-course (Tremblay et al., 1999), and some of the factors that influence misbehavior can be identified early in life while others emerge later in life (Stouthamer-Loeber, Wei, Loeber, & Masten, 2004). Second, these studies have charted the course of persistence (the fraction of the population who continues criminal activity over time), but less so on desistance (the fraction of the population who ceases criminal activity over time). This is so because many studies do not follow sample members past their 30s. Moreover, there is a long recognized difficulty in operationalizing desistance (Bushway, Piquero, Broidy, Cauffman, & Mazerolle, 2001; Laub & Sampson, 2001) and a recognition that there is much intermittency, or stops and starts, throughout an individual's criminal career that may be misconstrued as desistance (Laub & Sampson, 2003; Nagin & Land, 1993; Piquero, 2004). The issue of intermittency is one that is completely lost with cross-sectional studies. Third, longitudinal studies appear to suggest that the correlates of onset, persistence, and desistance may not necessarily be the same and that some factors influencing onset may have little to do with the factors that influence persistence or desistance (Piquero et al., 2003). Fourth, the advent of new methodological/statistical tools has aided researchers' ability to more directly examine individual and group-based patterns of criminal activity. One in particular is the trajectory methodology, which allows researchers to study how criminal activity changes over time in a group-based framework (Nagin, 1999). This methodology seems particularly well-suited to studying criminal activity over the life course because according to some developmental, group-based theories of crime (e.g., Moffitt, Patterson, Loeber) there may be different groups of offenders (low

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[1] Debates regarding the merits of longitudinal vs. cross-sectional designs exist elsewhere (see Blumstein, Cohen, & Farrington, 1988a, 1988b; Gottfredson & Hirschi, 1986, 1988).

rate, medium rate, and high rate), their offending trajectories may exhibit different shapes at different ages, and they may be differentially affected by distinct crime-exacerbating factors. Findings from this line of research appear to suggest that there is meaningful variation within offenders and the factors that predict the offending of one group are not necessarily the same as the factors predicting the offending of another group. Moreover, applications of this methodology to various data sets lead to the conclusion that developmental patterns of criminal activity differ with regard to crime type and whether offender-based samples are used. For example, offender-based samples yield higher and more stable rates of offending over longer periods of the life course.

Given the amount of research undertaken in recent years with this methodology and the unique window within which it provides criminologists the ability to peer into offenders' criminal careers, the rest of this essay will attempt to document what is known about the natural history of offending with the use of the trajectory technique. Consider this, then, a "taking stock" of what we have learned about developmental trajectories of criminal activity. The essay begins with a description of the trajectory methodology, followed by a review of the studies that have used this approach to document the longitudinal patterning of criminal activity, and closes with a summary statement of key findings and an identification of several future research directions.[2] Because the studies reviewed in this essay employ a varied array of sampling frames, and cover various periods of the life-course, the essay will describe the results of these studies by the type of sample used (offender-based/general population), as well as the time period covered (childhood/adolescence/adulthood). Before these studies are reviewed, a brief description of the theoretical debates that the trajectory methodology can help empirically assess is presented.

Theoretical Backdrop

A core issue in criminology is the shape of the age/crime curve, not the aggregate age/crime curve per se, but the age/crime curve at the individual level (Blumstein et al., 1986; Britt, 1992; Gottfredson & Hirschi, 1990; Greenberg, 1991; Le Blanc & Loeber, 1998; Loeber & Le Blanc, 1990; Nagin & Land, 1993; Piquero et al., 2003). Is this relationship the same for everyone such that external life events do not matter after ages 8/10 once self-control is developed as static/general theorists like Gottfredson and Hirschi claim? Or is it that variation within individuals over time in sources of informal social control (e.g., marriage, military, etc.) leads to changes in criminal trajectories after ages 8/10 as static/dynamic theorists like Sampson and Laub claim? Or even still, is the aggregate age/crime curve characterized by a

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[2] Of course, integrating findings across these studies is particular challenging because of differences in sample characteristics, age ranges, length of follow-up measures, and analytic strategies and coding decisions (i.e., should crime information be dichotomized or left continuous?) (Tucker et al., 2005:309).

mixture of static/dynamic/developmental processes such that individuals may differ not only in their offending rates at any given age but also exhibit distinctive trajectories of offending over the life-course as hypothesized by Moffitt, Patterson, Loeber, and others? In short, the theoretical models described above make strong—yet competing—predictions about the development of criminal activity over the life-course.

These theoretical debates can be considered within the context of developmental criminology, which refers to the study of temporal within-individual changes in offending over the life-course (Le Blanc & Loeber, 1998:117). Importantly, the theoretical processes reviewed above make fundamentally different predictions about the existence of groups. Both Gottfredson and Hirschi (1990:132, Figure 9) and Laub and Sampson (2003:248 and 249, 278 and 279) would likely offer that a group-based framework is both problematic and uncertain not only because of a tendency to reify groups that may "not, in fact, exist" (Sampson & Laub, 2003:587), but also because both sets of theorists suggest and find that all offenders, even the most high-rate of all offenders, desist.[3]

On the other hand, the developmental theoretical models advanced by Moffitt, Patterson, Loeber, and others are exclusively group-based. For example, Moffitt's (1993) developmental taxonomy predicts that two types of offenders characterize the age/crime curve, each of whom have a unique set of predictors and each of whom evince distinct offending patterns over the life-course. One of these groups, life-course persistent, comprises a very small subset of offenders, whose antisocial activity begins in early childhood, persists throughout life, and is unlikely to respond to points of intervention. Members of the life-course persistent group share deficits in neuropsychological functioning which, when met with family adversity and ineffective parenting, create very difficult children and adolescents who fail in multiple life domains and engage in all sorts of criminal activity, including violence. On the other hand, adolescence-limited offenders engage in adult-like antisocial behaviors (except violence) during adolescence largely due to the interaction between *recognition* of the maturity gap[4] and the peer social context. Most adolescence-limited offenders, because they do not suffer injurious childhoods, desist by the time adulthood approaches because of their ready stock of prosocial skills and recognition that they can now afford all of the previously coveted adult activities. For Moffitt then, the two groups of offenders evince unique causes as well as unique shapes, peaks, and changes in offending rates over the life-course.

Clearly, in order to adjudicate between Moffitt's predictions of distinct offender typologies versus the more single-group frameworks advanced by Gottfredson and Hirschi and Sampson and Laub, researchers need methodological/statistical

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[3] Although Sampson and Laub (2003) are critical of group-based theoretical models as well as statistical tools developed to find them (Sampson et al., 2004), they do suggest that there may be "multiple pathways to desistance" (Laub & Sampson, 2003:278); yet desistance is facilitated by a range of turning points in combination with individual actions for all offenders (Laub & Sampson, 2003:278).

[4] Here, the maturity gap refers to the adolescent's recognition that they physically resemble adults, but society places age restrictions on their partaking of adult activities.

techniques that have the ability to parcel out distinct offending trajectories that change in shape and level over time. One such methodology, which is the focus of the current chapter, is the trajectory method. Next, we turn to an overview of this methodology, which has become a staple in researchers' ability to study the theoretical models articulated above.[5]

The Trajectory Methodology

The use of finite mixture models has a long history in criminology, and the trajectory methodology owes a great debt to the rich history in criminal careers research that attempts to sort out within-offender heterogeneity (see Blumstein, Farrington, & Moitra, 1985; Blumstein & Moitra, 1980). Recognizing that there may be meaningful sub-groups within a population that follow distinctive developmental trajectories (Loeber & Hay, 1994; Moffitt, 1993; Patterson, 1993), Nagin and Land (1993) developed a modeling strategy that makes no parametric assumptions about the distribution of persistent unobserved heterogeneity in the population. Unlike other techniques, the semi-parametric mixed Poisson model assumes that the distribution of unobserved persistent heterogeneity is discrete rather than continuous, and thus the mixing distribution is viewed as multinomial (i.e., a categorical variable). Each category within the multinomial mixture can be viewed as a point of support, or grouping, for the distribution of individual heterogeneity. The model, then, estimates a separate point of support (or grouping) for as many distinct groups as can identified in the data.

It is important to remember that the trajectory groups *approximate* population differences in developmental trajectories. A higher number of points of support (groups) yields a discrete distribution that more closely approximates what may be a true continuous distribution (Nagin & Tremblay, 2005a, b). This is easily illustrated with an example. Figure 1 displays two panels (e.g., Nagin, 2005:47, Figure 3. 1). The first panel, (A), depicts the population distribution of some behavior, z, while the second panel, (B), replicates the same distribution but is overlaid with a histogram that approximates its shape. Panel (B) illustrates that any continuous distribution with finite end-points can be approximated by a discrete distribution (a histogram) or alternatively by a finite number of "points of support" (Nagin & Tremblay, 2005a, b). A higher number of points of support yields a discrete distribution that more closely approximates what may be a true continuous distribution (Nagin & Tremblay, 2005a, b).

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[5] The trajectory method, according to Nagin (2005:2), is "based upon a formal statistical model for conducting group-based analysis with time- and age-based data [and it] provides the capacity for testing whether the hypothesized trajectories emerge from the data itself...As such, it can be thought of as a methodology for identifying meaningful subgroups in time-based data. It also provides the capacity for statistically identifying the factors that both predict and alter these distinctive time-based progressions."
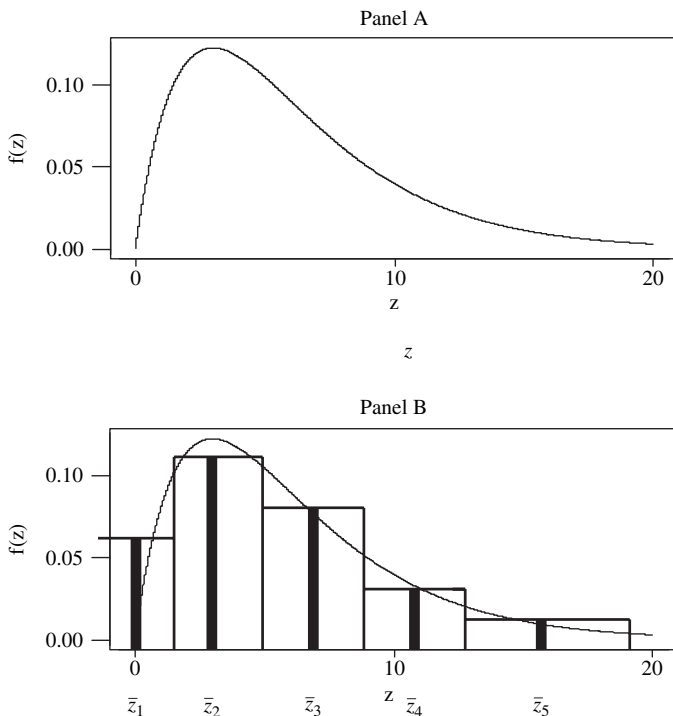
Panel A

f(z)

0.10

0.05

0.00

0   10   20

z

z

Panel B

f(z)

0.10

0.05

0.00

0   10   20

z

$\bar{z}_1$ $\bar{z}_2$ $\bar{z}_3$ $\bar{z}_4$ $\bar{z}_5$

Figure 1 Using groups to approximate an unknown distribution

Further, because each individual has a non-zero probability of belonging to each of the various groups identified, s/he is assigned to the group to which s/he has the highest probability of belonging to. This is a particularly important feature of this methodology because it allows researchers to assess the claims of extant developmental models that make predictions about different groups of offenders, including their size. This cannot be accomplished with approaches that treat unobserved heterogeneity in a continuous fashion.

The semi-parametric model (SPM) developed by Nagin and Land (1993) has three additional features that make it appealing for studying developmental trajectories of criminal activity. First, it makes use of a number of different estimators, including the Poisson, the zero-inflated Poisson, the Bernoulli, and the censored normal. The censored normal model is useful for psychometric scale data, the Poisson and the zero-inflated Poisson models are useful for count data, and the Bernoulli model for dichotomous data. By allowing for the use of different types of estimators, the outcome data under investigation can be more appropriately modeled. Second, the Poisson and zero-inflated Poisson versions of the model take into account periods of non-offending, or intemittency. Third, the group-based approach is more systematic in the way it categorizes offenders because it identifies distinctive groups by applying a formal, objective statistical criterion. Therefore, it avoids subjective

classification of individuals into groups that reflect only random variation.[6] In short, the trajectory methodology is well-suited for research problems with a taxonomic dimension whose aim is to chart out the distinctive developmental trajectories, to understand what factors account for their distinctiveness, and to test whether individuals following different trajectories also respond differently to an intervention (Nagin & Tremblay, 2005a, b).[7]

The results from employing the trajectory methodology are used in a number of ways, and they are documented in detail by Nagin (2005). Here, a few of the more common approaches are highlighted. First, the most common approach is to, after sorting individuals into the various trajectory classifications, treat the groups as nominal categories and then examine how an array of risk/protective factors vary across the groups. This is commonly referred to as the classify/analyze approach, and provides basic descriptive information regarding how the various trajectory groups differ along key variables of interest. Relatedly, researchers can use the trajectory groups as outcome variables in a multinomial logistic regression framework, where key independent variables are used to predict membership in the various groups. A second substantive analysis taken with the trajectory results is to use the group classifications as predictors, along with other key theoretical variables, in a regression-based framework to predict the outcome of interest (i.e., crime counts). This approach allows for an examination of how key theoretical variables, e.g., local life circumstances, relate to criminal offending after taking into consideration unobserved individual differences (measured through group membership) (for examples, see Laub et al., 1998; Piquero, Brame, Mazerolle, & Haapanen, 2002).[8]

Trajectories are not the only Approach

It must be recognized, of course, that the trajectory methodology is not the only approach one could take to study criminal activity over the life course. Alternative methods exist, principally hierarchical modeling and latent growth curve modeling.

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[6] Subjective classifications are quite often found in the literature. For example, Wolfgang et al. (1972) classified those individuals with five or more police contacts as "chronic" offenders. Other scholars categorize early- and late-starters based on an arbitrary age cut-off (i.e., 14). Blumstein et al. (1985) have shown that many of these arbitrary designations may not be supported by the data. At the same time, there may be some element of subjectivity involved when choosing between models identifying high numbers of trajectory systems. Nagin (2005:75) suggests that in certain instances when BIC is not a useful criterion for choosing a model, for reasons of parsimony and comprehensibility, "the fewer the groups the better". In short, Nagin (2005:77) recommends selecting a model with "no more groups than is necessary to communicate the distinct features of the data".

[7] Software and documentation to employ the trajectory methodology through the SAS platform is available at www.ncovr.org. Additionally, other statistical applications, such as LATENT GOLD and M-PLUS, also perform trajectory estimations, and other researchers have developed methods for trajectory methods including Bengt Muthén (see Muthén, 2004; Muthén & Muthén, 2000).

[8] In short, a major pragmatic advantage of the trajectory method is that it performs a major data reduction, such as the case in cluster analysis. The method allows one to reduce n individuals X t repeated measures of an outcome variable into k nominal groups for subsequent analysis.

One of the key differences between the trajectory approach and these other methods is that the latter treat the population distribution of criminal activity as continuous whereas the trajectory model approximates this continuous distribution with points of support, or groups. The trajectory method, then, is designed to identify distinctive, developmental trajectories within the population, to calibrate the probability of population members following each such trajectory, and to relate those probabilities to covariates of interest (Nagin, 1999:153).

Raudenbush (2001:59) provides a further clarification of the issues surrounding the various methodologies: "In many studies of growth it is reasonable to assume that all participants are growing according to some common function but that the growth parameters vary in magnitude." He offered children's vocabulary growth curves as an example of such a growth process. Two distinctive features of such developmental processes are (a) they are generally monotonic—thus, the term *growth*—and (b) they vary regularly within the population. For such processes it is natural to ask, "What is the typical pattern of growth within the population and how does this typical growth pattern vary across population members?" Hierarchical and latent curve modeling are specifically designed to answer such a question.

Raudenbush also offered an example of a developmental process—namely, depression—that does not generally change monotonically over time and does not vary regularly through the population. He observed (p. 59), "It makes no sense to assume that everyone is increasing (or decreasing) in depression. ... many persons will never be high in depression, others will always be high; some are recovering from serious depression, while others will become increasingly depressed." For problems such as this, he recommended the use of a multinomial-type method because development, or modeled trajectories, varies regularly across population members. Indeed, some trajectories vary greatly across population subgroups both in terms of the level of behavior at the outset of the measurement period and in the rate of growth and decline over time. According to Raudenbush (2001:60), the trajectory methodology is "especially useful when trajectories of change involve sets of parameters that mark qualitatively different kinds of development." For such problems, a modeling strategy designed to identify averages and explain variability about that average is far less useful than a group-based strategy designed to identify distinctive clusters of trajectories and to calibrate how characteristics of individuals and their circumstances affect membership in these clusters (Raudenbush, 2001:60).

Limitations of the Trajectory Methodology

As is the case with all methods that seek to understand the longitudinal patterning of criminal activity, the trajectory methodology is limited in some respects.[9] First, because the SPM assumes that unobserved heterogeneity is drawn from a discrete (multinomial) probability distribution, there will likely be model misspecification

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[9] For an excellent review of the various types and implications of latent trajectory models for the study of criminal and antisocial activity over the life course, see Curran and Willoughby (2003).

bias if unobserved individual differences are actually drawn from a continuous distribution.[10] Second, the identification of parameter estimates is difficult with small periods of observations and where the prevalence of observations is small. Third, classification of individuals to distinctive groups will never be perfect (Roeder, Lynch, & Nagin, 1999). Fourth, the number of groups extracted is variable (as shown in D'Unger, Land, McCall, & Nagin, 1998; Sampson, Laub, & Eggleston, 2004) and partly a function of sample size—the more individuals the more groups one is likely to find (see also Nagin & Tremblay, 2005a:30).[11] According to Sampson et al. (2004), this result is not surprising if indeed the underlying distribution is more or less continuous in nature. Still, the number of groups appears to plateau at about sample size 200, and the conclusions reached about the number of groups above this sample size do not vary much (D'Unger et al., 1998). Fifth, recent research seeking to understand how the model behaves under various conditions indicates that three more general concerns in longitudinal research, (a) length of follow-up, (b) the inclusion of incarceration time, and (c) data on involuntary desistance through death, influence developmental trajectories (Eggleston, Laub, & Sampson, 2004). Regarding length of follow-up, these authors found that length can influence group shape, peak ages, and group membership, and that the length of follow-up issue seems most relevant for high-rate offenders who continue offending into adulthood. Regarding incarceration time, they found that excluding such information results in underestimating the rate of offending and can affect group shape, peak age, and group membership, and that the incarceration information seems most relevant for high-rate offenders (see also Piquero et al., 2001). Regarding mortality, the analyses indicated that the population of the high-rate chronic group is greatly affected by the exclusion of mortality data (Eggleston et al., 2004:21). The issue here is that those who are dead are assumed to have desisted. And once again, mortality data seems most relevant for high-rate offenders. In short, longer-term data on offending and the inclusion of incarceration and mortality information alter the group number, shape, and group assignment in trajectory research.[12] Sixth, there have been some statistical concerns raised regarding the trajectory-based approach, specifically in an effort to address model fit to the data (Kreuter & Muthén, 2006a,b). According to Muthén (2007), two specific things are needed. First, analysts need to show that

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[10] Bauer and Curran (2003) recently argued that latent trajectory classes can be estimated even in the absence of population heterogeneity. In their simulation study, these authors asked if the components from the trajectory mixture model represent true latent subgroups in the population, or whether they were serving only to approximate what is in fact a homogenous but nonnormal distribution. On this last point they noted that nonnormality was in fact a necessary condition for the extraction of multiple latent components or classes (p. 345). Their results indicated that multiple trajectory classes were estimated and appeared optimal for nonnormal data even when only one group existed in the population. For a slightly different view/interpretation of this, see Nagin and Tremblay (2005a).

[11] However, if the underlying distribution is indeed discrete and not continuous, then an increase in sample size will not artificially lead to an increase in the number of groups identified.

[12] To be sure, these specific concerns also influence the other methodological techniques for studying criminal careers using longitudinal data (Nagin, 2004a). That is, hierarchical and growth-curve modeling techniques must also deal with these exact same problems.

the group-based model fits the data better than the standard HLM random effect model (with a single class) – otherwise, there are no meaningful groups to be found. Second, there needs to be an effort to show that a more flexible model – such as the growth mixture model that Muthén has proposed – does not fit significantly better than the group-based model. If it does, the group-based approach is insufficient and does not fit the data. This is oftentimes ignored in the group-based research tradition and may be regarded as statistically unacceptable especially because it could make a difference in substantive conclusions (see Muthén & Asparouhov, 2006: 17–20 to see what a difference the choice can make; see also Muthén, 2004, section 19.5.2). In short, Muthén (2006) argues that the group-based analysis field is poorly developed statistically and there exists some alternative modeling viewpoints.

Finally, Sampson et al. (2004) are concerned not with the model itself, but how the results emerging from it are interpreted. The issue here is that the method is vulnerable to misappropriation by those pre-disposed to believe in the idea of a high-rate group of offenders (pp. 38–39).[13] As these authors suggest, "The SPM [semi-parametric model] begins with the assumption that groups exist, often leading to the notion that a wide array of group configurations is possible. Is it then easy for the naïve user to conclude (tautologically?) that groups exist because they are discovered, even though a model cannot be said to discover what it assumes. SPM will estimate groups from an underlying continuous distribution, a fact that can bedevil even the most sophisticated user (p. 41)."

Recently, Nagin and Tremblay (2005a,b) have noted that there has been some confusion about the interpretation of the model, stemming primarily from the interpretation of what it means to say "person x belongs to trajectory group j." Three misconceptions in particular have been identified: (1) individuals actually belong to a trajectory group, (2) the number of trajectory groups in a sample is immutable, and (3) the trajectories of group members follow the group-level trajectory in lock-step (Nagin & Tremblay, 2005a).

With regard to the first caution, the methodology and its developers caution against reification of groups. Regarding the second caution, it must be remembered that the groups are intended as an approximation of a more complex underlying reality. Thus, what the model does is simply to display the distinctive features of the population distribution of trajectories. As such, the number of groups and the shape of each group's trajectory are not fixed. This is so because longitudinal data are limited not only by the number of individuals but more importantly by the number of periods or sets of observations for which individuals are observed. As more periods of data are added, trajectories may vary. As Nagin and Tremblay (2005a) surmise, "more data allows for more refined statistical inferences." Finally, because the trajectory methodology creates a summary that describes the behavior and characteristics of individuals following similar developmental courses (i.e., it summarizes the average behavioral trend of a collection of individuals), individuals assigned to

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[13] This is an interesting point because while most (if not all) criminologists agree that there is in fact a small, high-rate group of offenders, the debate seems to be more about what that observation means (i.e., is it a difference in degree or a difference in kind?). This issue has not been resolved and remains a legitimate subject of debate.

specific trajectory groups may not follow the overall trajectory pattern perfectly. In other words, it is not necessarily the case that all individuals in a trajectory will follow that trajectory, only that individuals assigned to a particular trajectory resemble one another and the overall trajectory moreso than they do another trajectory. In this regard, a group within the trajectory context is a cluster of approximately homogenous individuals in the sense that they are following about the same developmental course, and have distinctive characteristics from other clusters of individuals following different developmental courses (Nagin & Tremblay, 2005a).[14] In short, it must be remembered that: (1) individuals do not actually belong to a trajectory group; (2) the number of trajectory groups in a sample is not immutable; and (3) individuals do not follow the group-level trajectory in lock step.[15]

Review of Studies

We now turn to a review of the trajectory studies that have emerged in the literature, with a specific focus on criminal activity. Noted here is the fact that the group-based methodology has begun to permeate other disciplines and applications have been made to obesity (Mustillo et al., 2003), cocaine (Hamil-Luker, Land, & Blau, 2004) and marijuana/other drug use (Guo et al., 2002), binge-drinking (Chassin, Pitts, & Prost, 2002; Hill, White, Chung, Hawkins, & Catalano, 2000), cigarette smoking (Chassin, Presson, Pitts, & Sherman, 2000), women's employment patterns (Hynes & Clarkberg, 2005), women's public assistance receipt (Hamil-Luker, 2005), perceptions of depression (Stoolmiller, Kim, & Capaldi, 2005) and legal socialization (legitimacy and legal cynicism) (Piquero, Fagan, et al., 2005), software piracy (Piquero & Piquero, 2006), individual world-wide web usage (Christ, Krishnan, Nagin, Kraut, & Gunther, 2001), and so forth. However, for purposes of the current chapter, attention is paid in particular to criminal activity.

Appendix presents an overview of the papers that have used the trajectory methodology between 1993 and 2005. This appendix indicates the authors of the paper, the year of its publication, the sample used, the age, race, and gender of the subjects, the measurement of the outcome variable (official and/or self-reports), the number of groups identified, and some interesting findings emanating from the research. Because a listing and summary of each paper is beyond the scope of this chapter, the review of studies that follows is based on substantive efforts aimed at identifying trajectories. For ease of presentation, the studies are cataloged by whether they were based on an offender or non-offender sample, as well as whether the data presented a portrait of crime in childhood, adolescence, adulthood, or

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[14] It is important to bear in mind that the variation within the trajectory is random variation conditional on trajectory (group) membership, while the variation between the trajectories is structural.

[15] According to Muthén (2007) however, the group-based model does indeed assume that individuals belong to a trajectory group. His view is that to the extent that the trajectory methodology views this as merely an approximation, then researchers should use a growth mixture model where within-class variation is allowed.

some combination thereof. It is important to note the impressive array of studies employing this methodology. Over 80 studies have used the trajectory analysis in urban, suburban, and rural settings, in the US and abroad, and spanning birth to age 70, and integrating findings across these studies is particularly challenging because of differences in sample characteristics, age ranges, length of follow-up measures, and analytic strategies and decisions (e.g., Tucker, Ellickson, Orlando, Martino, & Klein, 2005:309). Nevertheless, such a review can begin the process of synthesizing key conclusions across empirical studies.

Methods Papers

There have been several methodologically-oriented papers written about the trajectory methodology, and in general these papers employ longitudinal data, identify distinct trajectories, and then discuss the strengths and weaknesses of this approach. These papers include: (Brame, Nagin, & Wasserman, 2006; Bushway, Brame, & Paternoster, 1999; Eggleston et al., 2004; Haviland & Nagin, 2005; Jones, Nagin, & Roeder, 2001; Kreuter & Muthén 2006a,b; Land, McCall, & Nagin, 1996; Land & Nagin, 1996; Land, Nagin, & McCall, 2001, Loughran & Nagin, 2006; Nagin, 1999, 2005; Nagin & Land, 1993; Nagin & Tremblay, 2005a,b; Roeder et al., 1999; Sampson & Laub, 2005; Wang, Brown, & Bandeen-Roche, 2005). Because they still employ data to identify trajectories, they are reviewed below but the specifics of the studies are not discussed in this section. Readers interested in a more detailed exposition of the methodology should consult these papers as well as Nagin (2005). Finally, two papers (Griffiths & Chavez, 2004; Weisburd, Bushway, Lum, & Yang, 2004) apply the trajectory methodology to the analyses of crime at street segments and census tracts. Since these are not concerned with an application of crime at the individual level, they are not reviewed here.

Substantive Papers

Offender Samples

There have been nine trajectory studies undertaken with offender samples. Four different data sets have been used, and all subjects were followed through portions of adulthood. Thus, no studies considering only childhood and/or childhood/adolescence are reviewed here. Three studies employ the Boston area delinquents (i.e., the Glueck sample) (Eggleston et al., 2004; Laub et al., 1998; Sampson & Laub, 2003), three involve cohorts of California Youth Authority parolees (Ezell & Cohen, 2005; Piquero et al., 2001, 2002), two involve a Dutch conviction cohort (Blokland, Nagin, & Nieuwbeerta, 2005; Blokland & Nieuwbeerta, 2005), and one involves an offenders index from the British Home Office

(Francis, Soothill, & Fligelstone, 2004).[16] In general, with the exception of the British data, the pattern and similarity of results from the Boston delinquents, the Dutch offenders, and the CYA parolees is striking.

Using data on 500 offenders paroled from California Youth Authority institutions and followed for seven consecutive years post-parole, Piquero et al. (2002) modeled joint trajectories[17] of violent and non-violent offending throughout the early 20s, as well as their covariates. A number of key findings emerged from their paper. First, four trajectories each were identified for violent and non-violent offending, but non-violent offending rates were always much higher than the violent offending rates. (These joint trajectory graphs are reproduced here in Figure 2). Second, when the trajectory systems were modeled jointly, one of the four systems (shown as Series 1) had a decreasing non-violent arrest rate, but an increasing and stable violent offending rate. Third, when these authors estimated the effects of various covariates on arrest activity after conditioning on group membership, they found that some of the covariates exerted different effects across the various groups on both violent and non-violent criminal activity. For example, their measure of stakes in conformity (which included employment and marriage) was inhibitive of non-violent arrests for their second trajectory system but had no effect whatsoever on the offending of their third trajectory system. Similarly, heroin and alcohol dependence was predictive of non-violent arrests for the second trajectory but no effect for violent arrests for the same trajectory. Finally, in an analysis that examined the effects of covariates on arrest activity and including controls for group membership, they found that non-whites were more likely to accumulate violent arrests, that heroin dependence was positively related to non-violent arrests, and a measure of stakes in conformity (including marriage and employment) inhibited non-violent arrests.

Analyses of the offending samples have consistently identified four to six trajectories. The Piquero et al. (2002) paper just discussed, which contains offending information through age 28 for a sample of CYA parolees, identified four trajectories (for both violent and non-violent arrests, respectively). When total arrests were analyzed, Piquero et al.'s (2001) analysis of a different sample of CYA parolees through age 33 converged on six trajectories. Ezell and Cohen's (2005) trajectory analysis for three different samples of CYA parolees (paroled in 1981–2/1986–7/1991–2) also each favored a six-group model. These trajectories differed both in overall level of offending and in the trajectory shape. For example, for the parolee cohort with the longest follow-up period (1981–2 sample, age 7–37), trajectories differed in average

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[16] A recent study in South Australia applied the trajectory methodology to the juvenile criminal careers of a 1984 birth cohort and identified six trajectories (Marshall, 2005), but this study only exists, at present, in presentation format.

[17] Unlike the modeling of a single outcome, joint/dual trajectory analyses model the developmental course of two distinct but related outcomes. According to Nagin (2005:141), the "dual trajectory model provides a rich, yet easily comprehended, statistical summary of the developmental linkages between the two outcomes of interest. It can be used to analyze the connections between the developmental trajectories of two outcomes that are evolving contemporaneously (such as depression and alcohol use) or that evolve over different time periods that may or not overlap (such as prosocial behavior in childhood and social achievement in adolescence)".

Expected Violent Arrest Rate
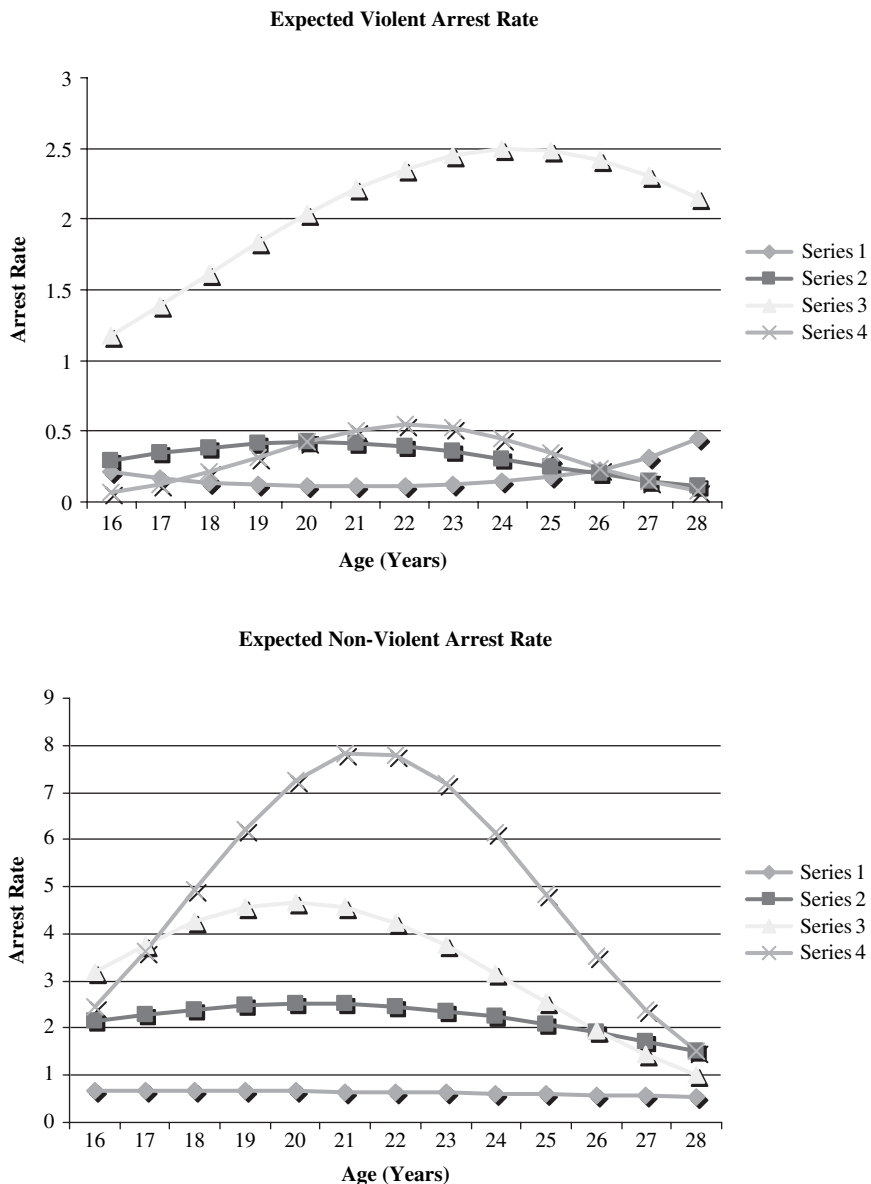

Expected Non-Violent Arrest Rate

Figure 2 Summary of violent and non-violent arrest trajectories under assumption of 12 months street time each year
(Source: Piquero et al., 2002, Fig. 2, p. 154)
Note: Trajectory group classification distribution was as follows: Series 1 = .145; Series 2 = .511; Series 3 = .124; and Series 4 = .220 (Piquero et al., 2002:153; Table 4)

arrest rates and also in terms of the growth and decline of arrests over time (Ezell & Cohen, 2005:185).

Similarly, when total arrests among the Boston males, first identified as delinquent at age seven, were analyzed to age 32, Laub et al. (1998) identified four trajectories. While all of these trajectories appear to be declining by age 32, one trajectory had a much higher offending peak than the other three groups. These "high rate chronics" consisted of only eleven individuals. Their offending peaked in the early 20s and then began a slow, gradual decline by the late 20s and early 30s. Laub et al. then examined the factors that were related to such trajectories, and found that after controlling for trajectory group membership, involvement in "good marriages" was inhibitive of continued criminal activity in early adulthood.

When Sampson and Laub (2003; Laub & Sampson, 2003) extended the data to include arrests through age 70, two other trajectories emerged for the total arrests analysis, thus totaling six distinct trajectory systems (p. 582, Figure 11, reproduced here as Figure 3). Three points are in order regarding these trajectories: (1) a small group of men, about 3.2%, were labeled as "high-rate chronics", whose offending activity peaked in the late 30s, and then dropped close to zero by age 60; (2) three other trajectory groups peaked in middle adolescence, late adolescence, and early adulthood respectively, and then began a slow decline toward zero in adulthood; and (3) a small group of offenders, "low-rate chronics", representing about 8% of the sample, had a steady offending trajectory between the ages of 19 and 39, at which point their offending began to decline. Controlling for exposure time (with data through age 32), had the interesting effect of only identifying five groups, but the predicted number of offenses was much higher with exposure time taken into
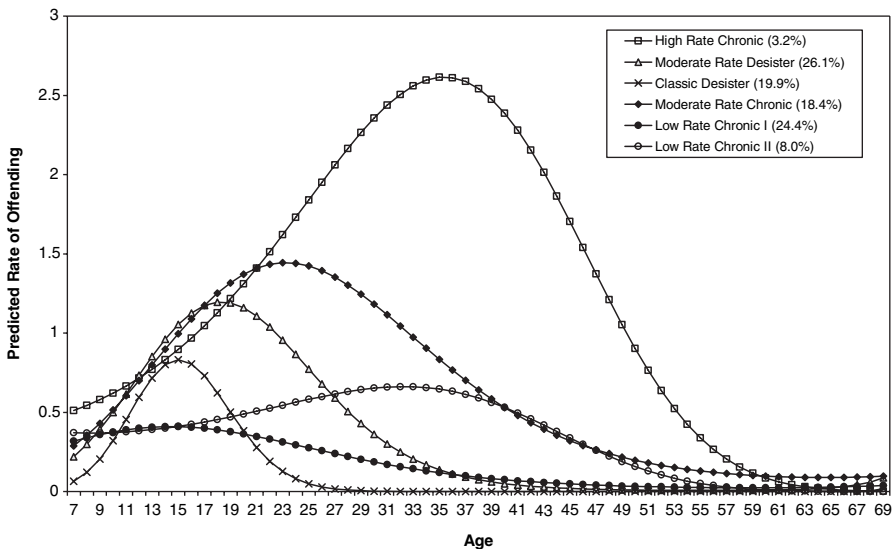

Figure 3 Official arrest trajectories—Glueck Males—ages 7–70
(Source: Sampson & Laub, 2003, p. 582, Figure 11.)

consideration. Still, by age 32, the offending patterns in the exposure time analysis appeared to diminish.[18]

The second main finding from the Sampson and Laub (2003) follow-up study concerned the crime-specific trajectories. With regard to violent crime, although there were five distinct trajectory groups, the mean rate of offending was always low for these groups (never above 0.4 arrests per year). Still, the offending trajectories for violent offending were quite erratic; that is, all five groups, while having somewhat similar shapes, differed in their peaks and their declines. For alcohol/drug offending, once again five trajectories were observed, with the majority peaking in the mid to late 30s, and then evincing a decline through middle to late adulthood.

The third key finding concerned the comparison of selected childhood/adolescent risk factors by trajectory group membership. These results showed inconsistent patterns and no statistically significant differences in means across the six groups of offending (for total crime only), though the trend was to show that the high-rate chronic group did evince the worst risk factors. It is likely that the differences did not emerge as significant because there were only fifteen men in the high-rate chronic group for which to make comparisons. Sampson and Laub conclude that "life-course-persistent" offenders seem to stop offending by middle adulthood and that they are difficult to identify prospectively using a wide variety of childhood/adolescent risk factors. It is also worth noting here that the age 7–70 Boston sample may not only be the longest longitudinal dataset in the world, but also is the first to track the offending of serious delinquents throughout the full life course. Analyses from this dataset find no evidence of a flat-trajectory group with age, which has been previously undetected because of middle-adulthood censoring (see Laub & Sampson, 2003:105).

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[18] It is interesting to note that in Sampson and Laub (2003), the authors, when considering the mean number of days incarcerated per year between ages 7–32, are able to reproduce the classic aggregate age/crime curve and conclude that the trajectories are very similar with street time taken into consideration. In their companion book, Laub and Sampson (2003:100–103) conclude that the age-crime curve and the similarity of offending trajectories is stable (p. 103). Yet in Eggleston et al. (2004), the authors reach a somewhat more guarded conclusion. Aside from the fact that the predicted level of offending is much higher when incarceration is taken into consideration, offending is predicted to peak at an older age (23 as opposed to 20), and there is a fair amount of instability with the moderate-rate chronic group of offenders: "Thirty-nine percent of the moderate-rate chronics in the model without the incarceration parameter are also in this group when incarceration time is included. In other words, over 60% of the men are no longer identified as moderate-rate chronics once incarceration time is taken into account" (pp. 17–18). Moreover, the differences with and without exposure time are most dramatic in the high-rate chronic group: "With incarceration time in the model, offending peaks in the early twenties at about six offenses per year and slowly declines thereafter to 1.5 offenses per year by age 32. Without incarceration in the estimation, offending consistently increases into the early twenties before leveling off at about 2 offenses per year" (p. 19). Importantly, "56% of the high-rate chronics in the model without incarceration are no longer classified as high-rate chronic offenders when incarceration is taken into account" (p. 19). They conclude that "the exclusion of incarceration time results in underestimating the rate of offending and can affect group shape, peak age, and group membership" (p. 21).

The Dutch offender data and trajectory results provide a counter-point to the Boston-area studies. Blokland et al. (2005) used conviction data for a sample of 5,164 Dutch offenders over an age span from ages 12–72 and identified four trajectory groups: sporadic offenders, low-rate desisters, moderate-rate desisters, and high-rate persisters. Importantly, the high-rate persisters engaged in crime, especially property crime, at a very substantial rate even after age 50, and their estimated trajectory resembled a fairly flat and stable average conviction rate through age 72. When comparing their findings to those obtained by Sampson and Laub (2003:588), Blokland et al. (2005:944) indicate that while about 98 percent of the individuals in their sample follow offending patterns similar to those observed in the Boston-area studies, whom would likely be characterized as "life-course-desisters", a small group of persistent offenders, making up less than two percent of the sampled population, exhibits a relatively flat trajectory of about 2 to 2.5 convictions per year from age 30 onward, and "does not conform with the Sampson and Laub conception of life-course desisters. Their course of offending is in fact best described by the Moffitt label of life-course persisters." In a companion piece, Blokland and Nieuwbeerta (2005) found that life circumstances (work, becoming a parent, and marriage) substantially influenced the chances of criminal behavior, and that the effects of these circumstances on offending differed across offender groups. For example, in general, high-rate offenders were less affected by life circumstances when compared to other trajectory groups, while marriage was associated with a drop in conviction rates among those in the low-rate trajectory group (p. 1224).

The British data and analysis are somewhat unique not only because they are of a birth cohort born in 1953 and followed-up with criminal conviction records in 1993 at age 40, but because it approaches the trajectory issue in a slightly different way. Francis et al. (2004) first search for latent types of criminal activity and then aggregate criminal careers into fixed five-year age periods of each offender's criminal history. Focusing more on types of crimes within clusters over time (i.e., they did not assign individuals to clusters), these authors identified nine different male clusters and three different female clusters.[19] For example, male offending showed greater diversity than female offending. Additionally, for males, each type of offending had a distinct age profile, but this was not evident with the females (Francis et al., 2004).

In sum, the pattern of findings emerging from the offender-based samples, especially the two very different Boston delinquent and CYA parolee samples, which are not only based on different "types" of delinquents but also in different contexts and time periods, points to two findings. First, offending appears to decline as early adulthood approaches for all groups. Second, there appear to be about 4–6 distinct trajectories, on the higher end with more data (i.e., length of observation window), as is expected (Nagin & Tremblay, 2005a). Unfortunately, given the small number of studies that have used offender-based samples, and the limited capacity that such

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[19] In the Francis et al. study, each individual can contribute up to six strips (offending age bands), and each strip could theoretically be assigned to a different cluster. The interest underlying their work was an examination of how offenders change their offending behavior as they age (i.e., quality or nature of offending as opposed to quantity of offending).

studies have for prediction-based analysis, little information is known about the factors that relate to trajectory differences within serious offenders followed into adulthood. Laub et al. (1998) and Laub and Sampson (2003) have shown that good marriages lead to low offending trajectories, while Piquero et al. (2002) have found that a mixture of stakes-in-conformity and alcohol/heroin dependence relate to criminal activity (sometimes violent, sometimes non-violent) differently across different trajectories: whereas stakes-in-conformity decreased crime, heroin dependence increased it. Similarly, Blokland and Nieuwbeerta (2005) found that marriage had an inhibitory effect on crime for some trajectory groups but not others (i.e., high-rate offenders). Importantly, the substantive results emerging from these studies were observed even after controlling for trajectory group membership, which as noted earlier is one vehicle for controlling for unobserved individual differences. That these effects emerged after controlling for such unobserved individual differences indicates that the effects are quite real.

General Population Samples

There are over a dozen unique US-based longitudinal studies that have employed the trajectory methodology, most of which have used data from the 1958 Philadelphia Birth Cohort Study. Some of these studies have been based on strictly general population and/or birth cohort samples, while others have made use of more high-risk, urban samples (such as the OJJDP-funded Pittsburgh Youth Study and the Rochester Youth Development Study). Other national datasets have contributed to this line of research including the 1945 Philadelphia Birth Cohort Study, the three Racine, WI cohorts, the National Longitudinal Survey of Youth, the Seattle Social Development Project, the Oregon Youth Study, and so forth. A number of international studies have also been undertaken including several using data from the South London males participating in the Cambridge Study in Delinquent Development (CSDD, used nine different times) as well as the Montreal Longitudinal Studies (used ten different times). Other internationally based longitudinal studies that have employed the trajectory methodology include the Christchurch and Dunedin Health and Human Development Studies, and the Quebec Longitudinal Study. In short, it is likely that the data which have been used the most (the 1958 Philadelphia Birth Cohort Study and the Cambridge Study in Delinquent Development) have done so likely because they are both publicly available and because they contain yearly observations of criminal activity for relatively large samples of individuals into the mid 20's (Philadelphia) and into the 30's and beyond (South London). As other longitudinal studies age and data become publicly available, there is no doubt that they too will be used in great detail.

Here, these studies and their overall findings are grouped by the time period examined: (1) childhood only, (2) adolescence only, and (3) childhood/adolescence/adulthood. (Note: Adulthood is defined here as post age 20). No studies were located that used the trajectory methodology on an adult-only general population sample.

Childhood

Only five studies used data in the first ten years of life. Broidy et al. (2003) used data from six different longitudinal studies, and one of these in particular was the Pittsburgh Youth Study, which covered a portion of the first decade of life. Based on teacher- and self-reports between the ages of 7.5 and 10.5, Broidy and her colleagues found that there were four distinct trajectories of physical aggression among the Pittsburgh boys. Interestingly, though not surprising, all four trajectories of physical aggression were increasing over the age range studied. This may be due to the fact that the males were entering late childhood/early adolescence and/or because a subset of the Pittsburgh males was recruited from high-risk areas.

In the second paper, Tremblay et al. (2004) used maternal assessments of physical aggression at 17, 30, and 42 months from 572 Quebec families who had a five-month old infant. Using the trajectory methodology, three distinct clusters of physical aggression were identified (little aggression, modest aggression, and high aggression). The best predictors before or at birth of the high physical aggression trajectory group, comprising about 14% of the sample, were having young siblings, mothers with high levels of antisocial behavior before the end of high school, mothers who started having children early, families with low income, and mothers who smoked during pregnancy. At five months of age, the best predictors were mothers' coercive parenting behavior and family dysfunction.

In a ten-city, large scale study (Study of Early Child Care and Youth Development) conducted by the National Institute of Child and Human Development (NICHD, 2004), maternal ratings of offspring aggression were collected between ages two and nine on 1,195 subjects. Trajectory analyses indicated that a five-group model provided the best fit to the data, comprised of groups corresponding to very low, low, moderate/declining, moderate, and high trajectories. Specifically, while all five trajectories evinced different starting points, they all tended to decrease in mother-rated aggression from ages two to nine. Additionally, several variables were able to distinguish membership across the five trajectory systems.

Finally, in two separate papers, Shaw, Gilliom, Ingoldsby, and Nagin (2003) and Shaw, Lacourse, and Nagin (2005) examined trajectories leading to school-age conduct problems among 284 low-income boys in the Pittsburgh metropolitan area. Using the trajectory methodology, four distinct groups of overt conduct problems were identified between ages two and eight. Further analyses indicated that while all four groups were evincing declines in parental-reports of conduct problems, the groups differed on various risk factors such as maternal depression, maternal rejecting parenting, and fearlessness. In a subsequent paper, the authors assessed developmental trajectories of conduct problems and hyperactivity from ages two to ten and identified four trajectories for each outcome, and one in particular—the chronic trajectory on hyperactivity/attention problems, remained high and stable throughout the observation period. The authors also reported some overlap between conduct problems and hyperactivity, but the overlap was far from complete.

Childhood and Adolescence

Over twenty studies have applied the trajectory methodology to longitudinal data through adolescence, with the Montreal Longitudinal Study and Seattle Social Development Project accounting for several of these efforts.

Several common themes emerge from these studies. First, the majority of these efforts use self-reports of a varied nature (teacher, parent, and self) to document developmental trajectories. Second, many of these studies examine what psychologists call externalizing behaviors which are not always delinquent behaviors, such as conduct problems, physical aggression, oppositional behavior, hyperactivity, non-aggression, delinquent peer affiliations, fearfulness, helplessness, and so forth. Third, a few of these studies examine multiple or joint/dual trajectories such as violent/non-violent offending (Brame et al., 2001b), or childhood/adolescent aggression (Brame et al., 2001a; Nagin & Tremblay, 2001a, b).

Two studies in particular are worth highlighting. First, Nagin and his colleagues (2003) examined whether an important life event, grade retention, affected the life-course of physical aggression, and whether its impact varied according to the age at which the turning point occurred. Using data from 1,037 males aged 10–15 participating in the Montreal Longitudinal Study, they found that the influence of grade retention depended on the developmental course of physical aggression, but that the evidence regarding timing was less clear.

In particular, three main conclusions can be drawn from this paper. First, of four distinct trajectory groups identified, grade retention had the largest impact for the two largest trajectory groups ("moderate declining" and "high declining"), but had no impact upon the physical aggression of those in the "low" and "chronic" groups. Second, regarding the timing hypothesis, Nagin et al. found that the effect of grade retention on physical aggression was unrelated to timing for the "high declining" group, but that it mattered for the "moderate declining" group such that for these individuals grade retention aggravated classroom physical aggression when it occurred prior to age 13 but not after age 13. In short, the effects of grade retention appear to depend upon an individual's developmental history. Third, given trajectory group membership, the results showed that the impact of grade retention on physical aggression appeared unaffected by the child's early life characteristics and circumstances implying that any impact of grade retention on physical aggression was independent of pre-existing individual characteristics.

Second, Broidy and her colleagues (2003) used data from six sites (Montreal Longitudinal Study, Quebec Provincial Study, Christchurch Health and Development Study, Dunedin Multidisciplinary Health and Human Development Study, Pittsburgh Youth Study, and the Child Development Project (a three-site study in Knoxville and Nashville, TN and Bloomington, IN), and three countries (United States, Canada, New Zealand) to examine the developmental course of physical aggression in childhood (earliest age was six) through early adolescence (latest age was 15) and to analyze its linkage to violent/non-violent offending in adolescence. This analysis included whites and non-whites, males and females, and teacher- and self-report ratings in order to understand the development of disruptive behaviors. A number of key findings emerged from their effort.

First, in general, three or four trajectories were routinely observed across the six studies (e.g., four among boys in the Montreal Longitudinal Study, four for boys and three for girls in the Quebec Provincial Study, three for boys and girls, respectively, in the Christchurch Health and Development Study, three for boys and two for girls in the Dunedin Multidisciplinary Health and Human Development Study, four for boys in the Pittsburgh Youth Study, and three for boys and girls, respectively, in the Child Development Project). Second, while most trajectories of physical aggression were decreasing over the follow-up periods, one of the Child Development Project trajectories (for both boys and girls) was observed to be increasing and several of the Pittsburgh trajectories were observed to increase. The Pittsburgh result should not be too surprising since the last age of follow-up for the Pittsburgh males was 10.5 years; still, since half of the Pittsburgh sample was recruited as "high-risk", it would be interesting to see how long into adolescence the physical aggression trajectories continue on their upward path. Third, among boys across the samples, there was continuity in problem behavior from childhood to adolescence. In particular, chronic physical aggression increased the risk for continued physical violence as well as non-violent delinquency during adolescence. This finding however, was not replicated for females as there appeared to be no clear linkage between childhood physical aggression and adolescent offending among females. This is not meant to indicate that there were no females in the chronic physical aggression group, because there were females in that group; however, while males displayed similar patterns of physical aggression, there were mean-level differences (boys scored higher than females) in these trends and there was very little delinquency in adolescence among females. In sum, the trajectory groups, which were obtained via teacher reports, predicted involvement in delinquency in adolescence, obtained via self-reports. This suggests that there is continuity in problem behavior across informants from childhood into adolescence.

Aside from these two case studies, two summary statements can be made from the trajectory studies that cover the childhood/adolescence period. First, regardless of the use of self-, teacher-, parent-, or objective antisocial behaviors (including criminal and non-criminal outcomes), similar substantive conclusions have been reached regarding the shape/trend of the various trajectories. That is, by the end of adolescence, *most* trajectories, regardless of the outcome being assessed, are on a decline. Second and most importantly, it is impressive that across all the various studies in different parts of the world using different methodologies to measure criminal activity over a similar age range, there have been a consistent number of trajectories identified in these studies. Typically, three to four trajectories are identified, namely low, medium, and high groups.[20] Whether these groups continue in a similar fashion into adulthood is an important question because it deals with

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[20] This, of course, does not imply that more or fewer trajectories have not been identified in the trajectory studies covering the childhood/adolescence time period. For example, Nagin and Tremblay (2001b) identified six distinct trajectories based on self-reports of property offending. Interestingly, one of the groups, "rising chronic", comprised of 5.9% of the sample, started committing property offending at a high level at age 11 and continued high through age 17. Bongers et al. (2004) also identified six trajectories (of oppositional behavior) using longitudinal data from Holland. As

fundamental theoretical (are there two groups of offenders as Moffitt predicts?) and policy-related issues. And this is particularly important because some trajectory studies have identified a group of relatively late-onset offenders who appear to be increasing in antisocial activity. Data that follow these subjects into adulthood will be better able to continue charting the offending course of these late-onset chronic offenders. The next section reviews those studies that identify trajectories using data from childhood, adolescence, and adulthood.

Childhood/Adolescence/Adulthood

Close to thirty studies have applied the trajectory methodology to criminal and anti-social activity in a period covering childhood/adolescence/adulthood. These efforts have used longitudinal data from various locations in the United States, England, Canada, New Zealand, and so forth. Moreover, these efforts have employed random, non-random, and birth cohort samples, males and females, whites and non-whites (including blacks), and in some cases cover offending careers through age 70.

Several common themes cut across these studies. First, many of the studies have utilized both self-reports and official records (police contacts, arrests, and convictions) to study the shape and patterning of criminal activity over the life course. Second, although most efforts have focused on criminal activity, including violent and non-violent crime, others have examined non-criminal trajectories for binge drinking, heavy drinking, and cigarette smoking. Third, several efforts have paid attention to gender differences in criminal activity trajectories.

Because a review of each of these studies is beyond the scope of this chapter, five studies are highlighted. This section begins with a paper that set out to answer a very basic, yet fundamental question regarding offending trajectories: how many latent classes of delinquent/criminal groups are there?

In a 1998 paper, Amy D'Unger and her colleagues used data from three different longitudinal studies, the Cambridge Study in Delinquent Development (CSDD), the 1958 Philadelphia Birth Cohort, and the 1942, 1949, and 1955 Racine, WI birth cohorts. Using the trajectory methodology, these authors identified four latent classes in the CSDD, and five in the Philadelphia cohort. In the Racine data, five classes were detected for the 1942 and 1955 cohorts, but only four for the 1949 cohort.

Specifically, the four groups indicated in the CSDD data showed a non-offender class, a low-rate chronic group whose offending was small but sustained between ages 10 and 30, an adolescent-limited group whose offending peaked at age 16 and then declined to about zero at age 22, and a high-rate chronic group whose offending was always much higher than the other groups, peaked at about ages 18/20, and was approaching zero by age 30.

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indicated earlier, a key advantage of the trajectory methodology is its ability to identify distinct trajectories and then to examine how these groups differ on an array of covariates.

The Philadelphia results indicated five groups, two of which stand out: a high-rate adolescence-peaked group, peaking at age 16 and dropping to almost zero by age 21, and a high-rate chronic group who peaked at ages 17/18 and continued at a steady rate through the early and mid 20s, only to decrease toward the late 20s.

Finally, the three Racine cohorts evidenced pretty different patterns, though this may be due to the nature of offending in the Racine data (which included traffic contacts). The 1942 cohort, which yielded five classes, had three groups of interest: a late-onset chronic group, a group not theoretically anticipated in extant developmental criminology models, who evidence late-onset offending and then an increasing and sustained rate of offending through the 20s; a high-rate chronic group whose offending peaks earlier and then declines through the 20s, and a low rate chronic group who evinces a slow but steady rise in offending through the period between ages 15 and 25 only to decline slowly by the late 20s. The 1949 Racine cohort, where four classes were identified, had two groups of interest: the first, a high-rate chronic group whose offending peaked in the late teens, remained relatively stable through the early 20s, and then began to decline in the mid 20s; and a high-rate adolescence-peaked group whose offending also peaked at age 18 but then steadily dropped through the early to mid 20s. Finally, the 1955 Racine cohort, which also yielded evidence of five distinct classes of offenders, indicated three groups of interest: an early-onset adolescence-peaked group exhibiting an early onset, adolescent peak, and a precipitous decline through the early 20s; a high-rate chronic group who began a slow and steady increase at age eight, peaking at age 17, and slowly decreasing offending activity in the early 20s, and a late-onset adolescence-peaked group whose offending did not begin in earnest until age 15, peaking at age 18, and then dropping throughout the 20s.

In short, across all three data sets, the authors observed a consistent set of two classes of offenders: an adolescent-peaked group and a chronic group. Although identification of these groups is consistent with the extant developmental theories of Moffitt and Patterson, the proportion of sample members in these two groups was not as expected (i.e., the identified chronic group contained many more persons than extant theory would predict). Moreover, other findings from these data sets indicated that another group, a late-onset chronic group, routinely emerged, again calling into question the simple two offender-group typology.

Using longitudinal data from 808 youths who participated in the Seattle Social Development Project (SSDP), Chung, Hill, et al. (2002) sought to identify childhood predictors of different offense trajectories through age 21. Using a self-report measure of offense seriousness, these authors found five distinct classes of offenders: non-offenders, chronic offenders, late onsetters, desisters, and escalators. The last group in particular was one not anticipated by extant developmental theory. Regression analyses were employed to examine which childhood predictors (at ages 10–12) distinguished the offending of these five groups. Their analysis indicated that among initial nonoffenders at age 13, late onsetters were distinguished from nonoffenders by individual factors, while among youths already delinquent at age 13, escalators were distinguished from desisters by peer, school, and neighborhood factors. In short, it is important to point out that the escalator and desistor groups, which are not identified in Moffitt's or Patterson's theories, represent more

than half of the SSDP sample. That other studies have also identified such groups indicates that modifications are needed to these and other taxonomic theories that do not expect such groups, especially the escalating/late-onset chronic group of offenders.

D'Unger, Land, and McCall (2002) address the issue of sex differences in offense trajectories by examining the offending patterns of males and females in the 1958 Philadelphia Birth Cohort Study. Utilizing a random sample of 3,000 females and 1,000 males from the cohort, their trajectory analysis identified five trajectories for males and three for females.

Regarding the male trajectories, two groups in particular stood out: the high-rate adolescence-peaked group whose offending began in early adolescence, peaked at age 16, and then began a drop toward zero throughout late adolescence and early adulthood; and a high-rate chronic group whose offending, though not higher than the afore-mentioned group through age 19, remained stable between mid-adolescence and the mid 20s, only to begin to decline at that point.

Regarding the female trajectories, two of the three groups (the final group being the non-offender group) are worth describing. The first of these groups, the low-rate adolescence-peaked group, offended for about a seven-year span, peaking at age 15, and dropping soon thereafter. The second group, the high-rate adolescence-peaked group, evinced the highest rate of offending at every age, peaking at age 17 and then dropping throughout the early 20s. Aside from these differences, perhaps the main overall difference is that while there were similar shapes and trends across the groups, the male offending rates were always significantly higher than the corresponding female rates.

Bushway, Thornberry, and Krohn (2003) used self-report data from the Rochester Youth Development Study to examine issues related to desistance using the trajectory framework. Following their subjects from age 13.5 to 22, these authors examined whether key conclusions regarding desistance would vary according to two distinct definitions of desistance. The first was a "static" definition of desistance which classifies as desistors those individuals who offended at least once before age 18, but not afterwards (through age 22). Using this definition, 27.6% of the sample met the desistor definition. The second definition of desistance used a "developmental" definition which is based on the trajectory methodology. This definition not only indicates which individuals approach a zero rate of offending, but it also provides information regarding how long they have been there.

Their trajectory analysis identified seven distinct clusters of offenders, two of which approximated individuals who looked like they had desisted (p. 144, Figure 1, reproduced here as Figure 4). The authors however, settled on only one of these groups as fitting their definition of desistance (i.e., "experienced real change...and [provided] no evidence [of] an upswing of offending at the end of the period" (Bushway et al., 2003:143 and 144). Using this definition, 8.4% of the sample was classified as desistors. Interestingly, of the 291 individuals identified by the two methods as desistors, there was only agreement by the two methods in 4.8% of the cases. Thus, different proportions of the sample were classified as desistors and different people were classified as desistors. As Bushway et al. (2001) suggest, the trajectory methodology represents a unique approach to study the process of desistance.
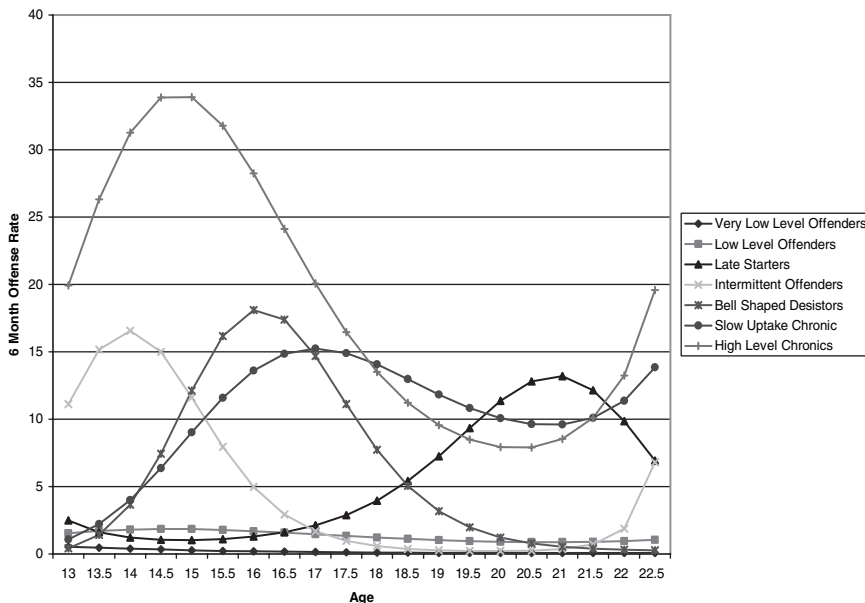
Figure 4 Self-report offending trajectories in the Rochester Youth Development Study (RYDS) (Source: Bushway et al., 2003: p. 144, Figure 1.)

Moffitt and colleagues applied the trajectory methodology to counts of conduct disorder symptoms assessed (via self-, mother-, and teacher-reports) for 525 males at ages 7, 9, 11, 13, 15, 18, 21 and 26 years in the Dunedin Multidisciplinary Health and Human Development Study (Moffitt, 2006). Their analysis detected five groups: (1) a life-course persistent group, comprised of 7% of the cohort, having a fairly stable high trajectory, and evincing more symptoms than any of the other groups at every age; (2) a group whose trajectory resembled an adolescence-limited pattern (14%), who began with two symptoms at age seven but increased to a peak of 4.5 symptoms at age 18, and then decreased on a slight downward trajectory to 3.5 symptoms at age 26; (3) a recovery group comprised of 21% of the cohort, who started at the same high point as the life-course persistent group but decreased steadily with age, having only one symptom by ages 21 and 26; (4) an abstainer group, comprised of 11% of the cohort, and having less than one symptom on average at every age; and (5) a low-level group (47%) who average about one symptom a year between ages 7 and 26. The pattern of conduct disorder regarding Moffitt's two offender typologies (adolescence-limited and life-course persistent groups) over the follow-up period were as expected. At age 26, males on the adolescence-limited trajectory were still engaging in property offending and substance abuse, but not serious offending, while males on the life-course persistent trajectory were elevated on mental-health problems and substance dependence, numbers of children sired, financial and work problems, domestic abuse of women and children, and drug-related and violent crimes.

Lastly, we close this section by reviewing two studies that employ the trajectory methodology in a novel way. Paternoster, Brame, and Farrington (2001) sought to examine the relationship between adolescent and adult conviction frequencies using the CSDD data. To examine this relationship, these authors first identified distinct trajectories using data through adolescence. This analysis yielded three trajectories, a group of low-rate offenders (including about 72% of the sample), a medium-rate offender group (comprised of about 23% of the sample), and a high-rate group comprised of about 5% of the sample. Then, after conditioning on adolescent offending behavior (using the trajectories), they asked whether variation in adult offending was consistent with a random process, and found that indeed it was. This implies that, after conditioning on adolescent variation in convictions, random variation in criminality during adulthood was sufficient to account for the adult conviction frequency distribution (Paternoster et al., 2001:213).

Because this finding challenges life-course views of criminal activity across age, and specifically the hypothesis that post-adolescent events matter in significantly altering the pattern of adult criminal activity, Piquero, Brame, and Moffitt (2005) sought not only to replicate the Paternoster et al. finding with a different data source, but also examine whether the finding could be replicated across gender. Using conviction data from ages 13 to 26 for males and females participating in the Dunedin Multidisciplinary Health and Human Development Study, Piquero and his colleagues not only replicated the main finding of the Paternoster et al. paper, but also replicated it across gender. Their full sample analysis, which yielded three trajectories, indicated that variations in adult offending through age 26 in the Dunedin data were consistent with a random process after conditioning on adolescent differences in the propensity to offend. Both the male analysis, which identified three trajectories, and the female analysis which identified only two trajectories, also led to the same conclusion.

Discussion

The purpose of this chapter is to take stock of what criminologists have learned regarding the longitudinal patterning of criminal activity using the trajectory methodology. Although not without its share of criticism, the group-based methodology is well-suited for the study of a behavior that does not vary regularly throughout the population (Raudenbush, 2001), but instead tends to reveal itself in markedly different intensities in sub-population clusters of individuals (Nagin, 2005), like crime. Here, a number of key findings that have emerged from this line of research are provided. The chapter closes by identifying a number of important research directions.

Use of group-based methods to estimate trajectories of criminal activity over the life-course suggests that there is a fair degree of consistency among and across a wide range of samples with respect to group number and shape, but that length of follow-up and age range may affect substantive conclusions regarding the shape of the trajectory (though this no fault of the methodology per se). It is imperative then,

that users bear in mind that the group-based approach is just an approximation. That being said, the current review of the various longitudinal studies centers on four main conclusions.

First, consistent with taxonomic theories of crime over the life-course (e.g., Moffitt, 1993; Patterson, 1993), trajectory-based empirical research does show an adolescent-peaked pattern and a chronic offender pattern, the latter which evidences declines in most studies. These findings emerge across a range of studies around the world, with different follow-up lengths, sample depictions, and use of self-, parent-, and teacher-ratings as well as different sources of official records including police contacts, arrests, and convictions. At the same time, the trajectory methodology has also identified another group of offenders not anticipated by most developmental, group-based theories. This late-onset chronic group, which begins offending in the middle to late portion of adolescence and continues offending at a steady rate into adulthood shows up in a number of different studies, regardless if offending is measured according to self-report or official records. Identification of this group is a good illustration of the value of the trajectory methodology because "continuous" methods would not have identified this group.[21] Further, some trajectory-based analysis indicates that some groups exhibit different age peaks than other groups (i.e., some peak in adolescence while others peak in early or middle adulthood, and sometimes these peaks vary across crime types—see Sampson & Laub, 2003). In short, the trajectory method has identified interesting peaks, shapes, and patterns of offending that bear relevance for criminological theory and that warrant continued exploration and explanation.

Second, on average, between three and five groups tend to be identified by the trajectory methodology, slightly more with self-reports than official records (likely due to more frequencies in the self-reports to partial individuals out better). That the methodology consistently identifies this number of groups in over 80 empirical studies certainly suggests some sort of generality in the findings.

Third, there has been some discussion regarding the identification of groups, and specifically the number of groups identified, dependent on sample size (Eggleston et al., 2004; Nagin & Tremblay, 2005a; Roeder et al., 1999). In one paper, D'Unger et al. (1998) drew three samples from the 1958 Philadelphia Birth Cohort of sizes 500, 1,000, and 2,000 and found that a model with five categories of offenders was robust to sample size. This is no small matter as it implies that, "rather than merely representing a discrete approximation to an underlying continuous distribution of unobserved delinquent/criminal propensity, the small number of latent offending categories estimated in [the] models may represent distinct classifications of offenders with respect to age trajectories of offending that are meaningful in and of themselves" (D'Unger et al., 1998:1622). In short, group characterization seems to be robust to sample sizes over 500.

Fourth, despite the varying numbers of latent offending classes, there clearly emerge a small number of typical age patterns. Generally, there tends to be a low rate

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[21] The use of the term "chronic" is solely illustrative. Criminologists need a new definition of the term chronic that goes beyond the flat λ definition and deals with both time and frequency.

group, a high rate group, a moderate but declining group, and a late onset group. At the same time, there is no simple answer to the number of groups because this varies by a wide range of conditions (i.e., the number of time points (more assessments, more trajectory groups), spacing of time points (annual spacing identifies more trajectories than bi-annual), informant method (self-reports identify more trajectories), conceptualization of outcome variable (delinquency scales generate more trajectories), age spans (longer age spans generate more trajectories), and time spans (longer studies yield more trajectories). It is also likely that the shape of the trajectories is due, in part, to the amount of information contained in the dependent variable(s). For example, self-reports of delinquency—especially in adolescence—contain very healthy offending frequencies, whereas police contacts, arrests, and in particular convictions, are likely to be thinner.

Where do we go from here?

It is clear that much has been learned about the longitudinal patterning of criminal activity via the trajectory methodology. But as is commonly case, answers to some questions open up a whole host of new questions. A number of these questions, organized into five broader areas of inquiry, are outlined below with the hope that researchers will find them sufficiently appealing to address.

The first set of questions deal with methodology and the robustness of findings, especially regarding the number of groups, across some methodological variation. First, earlier in this chapter, the observation was made that there is a slight tendency to uncover more trajectories—and with different shapes—in self-report records as opposed to official records. It may be then, that the greater amount of information available in self-report records allows for a better partialing of the offenders into more latent classes. There is a pressing need to document and understand these differences, and ideally such an investigation would be undertaken with a longitudinal sample followed from birth to adulthood that contain yearly observations of both self-report and official records. Second, there has been some work on the sensitivity of the trajectory methodology to non-random sample attrition, specifically incarceration and mortality (Eggleston et al., 2004; Piquero et al., 2001). Since both of these studies utilized official records, it remains unknown whether trajectories identified via self-report records also reveal similar sensitivities.[22] Further, there may be other forms of non-random sample attrition, such as refusal to continue participating in a longitudinal study, that are in need of studying within the context of the trajectory methodology. Third, there is a need to focus on individual-level variations within a trajectory group. Because individuals are assigned to the trajectory group to which they have the highest probability of belonging to, it is possible (and actually realistic) that some members may deviate from the overall pattern. It will be interesting to examine these deviations in further detail generally, and the factors

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[22] As stated earlier, the trajectory methodology is not the only approach that is sensitive to these issues. All other statistical techniques for studying crime over the life-course face the same concerns (Nagin, 2004a).

that are associated with such deviations specifically. Fourth, it is useful that the trajectory methodology allows and can control for periods of intermittency, or the stops and starts that characterize many offending careers. While theoretical explanations of the zig-zagging between offending and non-offending periods throughout individual criminal careers are lacking (Nagin & Land, 1993; Piquero, 2004) and are needed in order to develop more complete accounts of criminal activity, further exploration of intermittency within the trajectory method is needed especially across reporting method (official versus self-report records). Finally, there is a need for the kind of cross-site, cross-sample replication that was undertaken by Broidy et al. and D'Unger et al. where the same question was applied across a number of different data sources. While such research is difficult to undertake because of differences in measurement, operationalization, age/time spans, and so forth, it provides an important means of replication of substantive results.

A second set of questions deal with the exploration of more substantive issues. First, one of the key findings emerging from studies using the trajectory methodology to identify longitudinal patterns of offending is the almost routine identification of a "late onset chronic" group. Because extant developmental theory does not anticipate this group (see Patterson, 1997 for an exception), theoretical modification is in order. Moreover, extant criminological theory must also come to grips with this group and further examine if the traditional processes assumed for all offenders (in terms of persistence and desistance) similarly hold for this group. Second, the study of desistance is central to matters of theory and policy and longitudinal studies are ideal for helping researchers better understand the process of desistance and its time-varying correlates. The trajectory methodology stands in a good position to study this question (Bushway et al., 2001; Laub et al., 1998), and the findings reviewed earlier by Bushway and colleagues (2003) using the trajectory methodology to study desistance in the Rochester Youth Development Study are illustrative. Future efforts should shy away from arbitrary desistance definitions and consider employing the trajectory methodology to study the desistance question. Third, Sampson and colleagues (2004) have called into question the existence of a stable group of high-rate offenders, or what Moffitt has termed the "life-course persistent" offender. One wonders whether Moffitt meant that life-course persistent offenders offend at similarly high, stable rates throughout their entire lives right up until their death (see Moffitt, 2006 for a counterpoint). Thus, while Sampson et al.'s findings are important in documenting that very few 70 year olds offend at stable rates, we do not think that Moffitt (and others) had this in mind when constructing their taxonomic theories (Piquero & Moffitt, 2005). Still, it would be interesting to examine whether Sampson and Laub's findings hold in other datasets, especially since prior research shows continued self-report criminal activity even in the absence of officially recorded criminal activity well into adulthood (see Nagin, Farrington, & Moffitt, 1995). Fourth, while researchers have begun to examine the role of gender with regard to offending trajectories (Broidy et al., 2003; D'Unger et al., 2002; Piquero, Brame, & Moffitt, 2005), there has yet to be an analysis that has examined race differences in offense trajectories over the life-course. Important questions emerge here: do Blacks have different trajectories than whites and/or Hispanics? Do these patterns differ across violent and non-violent crimes? Given that Blacks persist in crime longer than Whites (Elliott, 1994), and that this is due largely

to prevalence differences in violence over time, it seems important to document not only race differences in longitudinal patterns of crime and the factors associated with such trajectories, but also to do so across reporting method. As Moffitt (1994) anticipates more African-Americans in the life-course persistent group, this is an important theoretical hypothesis deserving of attention.

The third set of questions deals with changing contexts and changing life events and how they relate to trajectories. First, the Moving to Opportunity studies have demonstrated the importance of assessing the role of changing contexts on individual outcomes. However, to date, such an examination has not been considered with the trajectory methodology. For example, what happens to offending trajectories when individuals move from one context (say high poverty/high crime) to another context (say low poverty/low crime)? Or what happens when an individual changes school districts? What happens to their offending trajectory? What happens to their grades trajectory? These questions, as well as several not listed above, should prove to be very interesting applications of joint trajectory models. Second, and more generally, the use of the trajectory methodology stands in a unique position to examine how life events alter either upward or downward trajectories of offending holding individual differences constant (Nagin, Pagani, Tremblay, & Vitaro, 2003). Unfortunately, very few studies have been completed in this regard. One in particular that is worthy of exploration stands out: the joining of a gang and how that influences a criminal trajectory thereafter. Relatedly, the effect of life events on crime trajectory may vary according to the phase in the life-course in which the life event occurs; for example having a child at age 17 may exert a different kind of effect on crime when compared to having a child at age 27. In short, extensions of the trajectory methodology can be used to make causal inferences about the impact of turning points and interventions on developmental trajectories (Haviland & Nagin, 2005; Wang et al., 2005).

A fourth question concerns the relevance of the results emerging from trajectory applications for addressing policy-related questions. Here, a specific example is presented along with a specific word of caution. In the first example, consider the case where two trajectory systems start at the same point, but then go in two different directions (one stays high on crime while the other evinces a sharp decrease). The correlates associated with these two trajectories may differ and to the extent that they do, this would potentially imply different points of intervention (while at the same time recognizing that the same intervention may not be applicable to all offenders or even all offenders in a particular trajectory). At the same time, a specific word of caution must be noted. Researchers need to be careful that policymakers do not take high-rate chronic offenders (or whatever label is applied to the highest-rate offending group) and "do" something with them. The fear here, of course, is that the high level of offending portrayed by these individuals will make them candidates for specific and harsh punishment experiences.[23]

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[23] Stated differently, the risk is more about "doing something" to people *predicted to be* high-rate offenders. This is the classic problem of prospective identification of high-rate offenders (Gottfredson & Hirschi, 1986). The issue may be more magnified within the trajectory context, when group identification combined with the ever-present problem of reification seems to heighten the risk.

Finally, for the most part, the trajectory methodology has been used to identify distinct trajectory systems and determine how they vary along relevant covariates. Another interesting though under-developed use of the trajectory methodology is that by identifying distinct groups, it can afford researchers new opportunities. For example, if a researcher using the trajectory methodology identified four distinct offender groups by age 18 using police arrest data, s/he could then take a random sample of five or ten individuals from each of those groups and then conduct a series of qualitative interviews from members of each trajectory system. This approach allows the trajectory methodology to use the empirical information to form a qualitative component to the study without selecting individuals based on some relatively arbitrary criterion.

This chapter reviewed what has been learned about crime over the life-course with the adoption of the trajectory methodology. This new method is being used increasingly often and offers some glimpses to criminal activity that are unavailable with other methods. Of course, this does not mean that this approach is superior to other approaches; it is but one in the criminologist's toolkit. Researchers studying the natural history of offending have at their disposal a number of important methodological tools that can be used to document the patterning of criminal activity. All of these tools make assumptions, and all of these tools have both strengths and weaknesses. Research should capitalize on these strengths, develop approaches that recognize and modify weaknesses, and continue to investigate the issues addressed in this chapter. Replication and convergence of substantive conclusions across different methodologies, is important because it speaks directly to fundamental debates in the field of criminology in general, and developmental criminology in particular.

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Appendix Group-based studies, 1993–2005, in order of publication

Authors	Year	Sample	Age	Race	Gender	Outcome Variable	Number of Groups	Interesting finding
Nagin and Land	1993	South London (CSDD) (n = 411)	10–32	White	Males	Convictions	4	First paper to use group-based methodology
Nagin et al.	1995	South London (CSDD) (n = 411)	10–32	White	Males	Convictions Self-reports (ages 10–14, 15–18, 28–32)	4	AL-group had no convictions, but did self-report drinking, drugs, and fighting
Land, McCall, and Nagin	1996	1958 Philadelphia Birth Cohort (n = 1,000 random subsample)	8–26	White Non-White	Males	Police contacts	4	
Land and Nagin	1996	South London (CSDD) (n = 411)	10–32	White	Males	Convictions	3	
D'Unger et al.	1998	(1) South London (CSDD) (n = 411); (2) 1958 Philadelphia Birth Cohort (n = 27,160); (3) 3 Racine, WI cohorts, n = 353–1942 cohort, n = 721–1949 cohort, n = 1,067–1955 cohort.	(1) 10–32 (2) 8–26 (3) 1942 cohort, 8–30, 1949 cohort, 8–25, 1955 cohort 8–22	(1) white (2) white/black (3) white/black	(1) males (2) males (3) males	(1) convictions (2) police contacts (3) police contacts	(1) four (2) five (3) 1942-five 1949-four 1955-four	
Laub et al.	1998	Boston area delinquents (n = 500)	7–32	White	Males	Arrests	4	Marriage effect

Appendix (continued)

Authors	Year	Sample	Age	Race	Gender	Outcome Variable	Number of Groups	Interesting finding
Nagin	1999	(1) South London (CSDD) (n = 411) (2) Montreal Longitudinal Study (n = 1,037)	(1) 10–32 (2) 6–15	(1) White (2) White	(1) Males (2) Males	(1) Convictions (2) Teacher ratings	(1) 3 (2) 4 physical aggression, 3 symptoms of physical aggression	Illustrative article detailing methodology
Roeder et al.	1999	South London (CSDD) (n = 411)	10–32	White	Males	Convictions	4	Allow for uncertainty of latent class membership; develop a model for multivariate analysis of risk factors
Nagin and Tremblay	1999	Montreal Longitudinal Study (n = 1,037)	6–17	White	Males	Teacher ratings of externalizing behavior problems	4 physical aggression; 4 opposition; 4 hyperactivity	
Muthén and Shedden	1999	NLSY1979 (n = 935)	18–25	White Non-White	Males Females	Self-reports	3	Heavy drinking
Bushway et al.	1999	1958 Philadelphia Birth Cohort (n = 13,160)	6–26	White Non-White	Males	Police contacts	3	
Fergusson, Horwood, and Nagin	2000	Christchurch Health and Development Study (n = 1,265)	1–18	White	Males Females	Self-reports	4	

Author	Year	Study/Sample	Age	Race	Sex	Reports	Groups	Notes
Muthén and Muthén	2000	NLSY1979	18–30	White Non-White	Males Females	Self-reports	4	Heavy drinking
Maughan, Pickles, Rowe, Costello, and Angold	2000	Great Smokey Mountains (n = 1,419)	9–16	White Non-White	Males Females	Self-reports Parent reports	3 aggression; 3 non-aggression	Boys had more aggression than girls.
Hill et al.	2000	Seattle Social Development Project (n = 808)	10–21	White Non-White	Males Females	Self-reports	4	Focused on binge-drinking and adult outcomes
Jackson, Sher, and Wood	2000	Freshman Midwestern University (n = 449)	18.5–24	White Non-White	Males Females	Self-reports	5	Examined alcohol-tobacco use disorder comorbidity
Chassin et al.	2000	Midwest Cohort Sequential Study of Natural History of Smoking (n = 8,556)	12–18 through 21–31	White	Males Females	Self-reports	6 initially, but settled on 4	Cigarette smoking
White, Johnson, and Buyske	2000	New Jersey Telephone Survey	15–28	White Non-White	Males Females	Self-reports	4 alcohol; 3 cigarette use	Alcohol and Cigarette Use

Appendix (continued)

Authors	Year	Sample	Age	Race	Gender	Outcome Variable	Number of Groups	Interesting finding
Colder et al.	2001	Project Star (n = 323)	11–13 through 15–17	White Non-White	Males Females	Self-reports	5	Cigarette smoking
Land et al.	2001	South London (CSDD) (n = 411)	10–32	White	Males	Convictions	2	Concerned with hidden heterogeneity issue
Brame et al.	2001	Montreal Longitudinal Study (n = 1,037)	13–17	White	Males	Self-Reports	3 childhood aggression; 6 adolescent aggression (but focus on 4); 7 joint childhood & adolescent aggression	
Jones et al.	2001	South London (CSDD) (n = 411) Montreal Longitudinal Study (n = 1,037)	(1) 10–32 (2) 10–15	(1) white (2) white	(1) males (2) males	(1) convictions (2) teacher ratings of oppositional behavior	(1) 4 using counts, 3 using prevalence (2) 5	
Piquero et al.	2001	California Youth Authority parolees (n = 272)	18–33	(1) white (2) non-white	males	arrests	6 with exposure time; 6 without exposure time	Size and shape of groups vary with and without controls for exposure time

Patemoster et al.	2001	South London (CSDD) (n = 411)	10–17 18–40	White	Males	Convictions	3 for adolescent convictions	Use adolescent groups to predict adult conviction frequencies
Nagin and Tremblay	2001a	Montreal Longitudinal Study (n = 1,037)	6–15	White	Males	Teacher ratings of physical aggression, oppositional behavior, hyperactivity, inattention, anxiety, and prosocial behavior	4	
Nagin and Tremblay	2001b (Psych Methods)	Montreal Longitudinal Study (n = 1,037)	6–17	White	Males	Teacher ratings (10–15) Self-reports (11–17)	4 in teacher reports; 6 in self-reports of property crime	
Brame et al.	2001	1945 Philadelphia Birth Cohort (n = 9,945) 1958 Philadelphia Birth Cohort (n = 13,160)	(1) 10–17 (2) 10–17	White Non-White	Males	Police contacts	(1) 3 (2) 3	Examined association of violent and non-violent crime over time
Li, Duncan, and Hops	2001	Longitudinal Study in Two Northwestern Urban Areas (n = 179)	11–18	White Non-White	Males Females	Self-reports	2	Alcohol use

Appendix (continued)

Authors	Year	Sample	Age	Race	Gender	Outcome Variable	Number of Groups	Interesting finding
Cote, Zoccolillo, Tremblay, Nagin, and Vitaro	2001	Quebec Longitudinal Study (n = 820)	6–12	White	Females	Teacher ratings of disruptive behaviors	4	Female specific analysis examining predictors of conduct disorder
Christ et al.	2001	HomeNet Project (n = 339)	Unknown	Whites Non-Whites	Males Females	Computer-generated use records of internet use	4	Examined internet use trajectories
White, Bates, and Buyske	2001	Rutgers Health and Human Development Project (n = 698)	T1 (12–18)T4 (25–31)	White Non-White	Males	Self-Reports	4	Persistent delinquents only scored higher than adolescence-limited delinquents on one risk factor, disinhibition
White, Pandina, and Chen	2001	New Jersey Telephone Survey	T1 (12)T5 (30/31)	White Non-White	Males Females	Self-reports	3	Cigarette use
Cote, Tremblay, Nagin, Zoccolillo, and Vitaro	2002a	Quebec Longitudinal Study (n = 1,569)	6–12	White	Males Females	Teacher ratings of hyperactivity, fearfulness, helpfulness	Hyperactivity: 4 for boys/girls; Fearfulness: 3 for boys/girls; Helpfulness: 3 for boys/girls	Used combinations of groups to predict conduct disorder

Author	Year	Study	Age	Race	Gender	Measure	Trajectories	Notes
Cote, Tremblay, Nagin, Zoccolillo, and Vitaro	2002b (JCPP)	Quebec Longitudinal Study (n = 1,865)	6–12	White	Males Females	Teacher ratings of impulsiveness, fearfulness, helpfulness	Hyperactivity: 4 for boys/girls; Fearfulness: 3 for boys/girls; Helpfulness: 3 for boys/girls	Descriptive paper
Fergusson and Horwood	2002	Christchurch Health and Development Study (n = 1,265 – 896)	12–21	White	Males Females	Self-reports Parent/ Teacher reports of conduct problems	5	
Chassin, Pitts, and Prost	2002	Longitudinal Study of Binge Drinking (n = 454)	12–23	White Non-White	Males Females	Self-reports	4	Binge-drinking
Li, Barrera, Hops, and Fisher	2002	National Youth Survey (n = 188)	14–18	White Non-White	Males Females	Self-reports	2	Alcohol use
Colder, Campbell, Ruel, Richardson, and Flay	2002	No-Treatment Control Condition of the Television, School, and Family Smoking Prevention and Cessation Project (n = 1,918)	Grades 7–12	White Non-White	Males Females	Self-reports	3 (frequency) 4 (quantity) 5 (quantity & frequency)	Alcohol use
D'Unger et al.	2002	1958 Philadelphia Birth Cohort (n = 3,000 females, 1,000 males)	10–26	White Non-White	Males Females	Police contacts	3 females 5 males	Similar patterns across gender, but higher lambda for males

(continued)

Appendix (continued)

Authors	Year	Sample	Age	Race	Gender	Outcome Variable	Number of Groups	Interesting finding
Chung, Hill, Hawkins, and Gilchrist	2002	Seattle public school students (SSDP) (n = 1,053)	13–21	White, asian, black, other	Males Females	Self-reported offense serious-ness	5	Escalator group still offending into adulthood
Casswell, Pledger, and Pratap	2002	Dunedin Multidisciplinary Health and Human Development Study (714 drinkers)	18–26	White	Males Females	Self-reports	4 (typical quantity per occasion)3 (frequency of drinking)	Alcohol
Piquero et al.	2002	California Youth Authority parolees (n = 524)	16–28	White Non-White	Males	Arrests	4	Estimated violent and non-violent arrest trajectories simultaneously 4 trajectories emerged for violent and non-violent, respectively
Lacourse et al.	2002	Montreal Longitudinal Study (n = 1,037)	11–17	White	Males	Self-reports	6 theft; 6 vandalism; 6 phys aggress	
Chung, Hawkins, Gilchrist, Hill, and Nagin	2002	Seattle public school students (SSDP)	13–18	White, asian, black, other	Males Females	Self-reported offense serious-ness	5	

	Year	Study	Age	Race/Ethnicity	Sex	Data Source	Trajectory Groups	Notes
Guo et al.	2002	Seattle public school students (SSDP)	13–18	White, asian, black, other	Males Females	Self-reports	4 binge-drink; 5 cigarette use; 4 marijuana use; 3 other drug use	Used alcohol and drug trajectories to predict sexual behavior at age 21
Lacourse, Nagin, Tremblay, Vitaro, and Claes	2003	Montreal Longitudinal Study (n=1,037)	11–17	White	Males	Self-reports	3 groups of deviant peer affiliations	Looked at gang membership and crime
Tucker, Orlando, and Ellickson	2003	Rand Adolescent/Young Adult Panel Study (n=5,694)	13–23	White Non-White	Males Females	Self-reports	4 groups (non-bingers defined a prior, 5 total)	Binge-drinking
Broidy et al.	2003	(1) Montreal Longitudinal Study (n=1,037) (2) Quebec Provincial Study (n=2,000) (3) Christchurch Health and Development Study (n=1,265) (4) Dunedin Multidisciplinary Health and Human Development Study (n=1,037) (5) Pittsburgh Youth Survey (n=1,517) (6) Child Development Project (n=585 families)	(1) 6–15 (2) 6–12 (3) 7–13 (4) 7–13 (5) 7.5–10.5 (6) 6–12	(1) white (2) white (3) white (4) white (5) white/black (6) white/non-white	(1) males (2) males and females (3) males and females (4) males and females (5) males (6) males and females	Teacher ratings Self-reports	(1) 4 boys (2) 4 boys, 4 girls (3) 3 boys, 3 girls (4) 3 boys, 2 girls (5) 4 boys (6) 3 boys, 3 girls	Trajectories increasing in PYS.

Appendix (continued)

Authors	Year	Sample	Age	Race	Gender	Outcome Variable	Number of Groups	Interesting finding
Wiesner and Capaldi	2003	Oregon Youth Study (n = 204)	T1 (9 and 10) T2 (23 and 24)	White (mostly) Non-White	Males	Self-Reports	6 groups	There was more specificity than commonality in correlates of distinctive offending trajectories
Brame, Bushway, and Paternoster	2003	1958 Philadelphia Birth Cohort; sub-sample of 2,657 who were juvenile offenders	18–27	White Non-White	Males	Police contacts	3 using absolute specification, 4 using split-population specification	
Bushway et al.	2003	Rochester Youth Development Study (n = 846)	13.5–22	White Non-White	Males Females	Self-reports	7 (but only four are sizeable)	
Mustillo et al.	2003	Great Smokey Mountains Study (n = 991)	9–16	White	Males Females	Objective measures of weight/height	4	
Schaeffer, Petras, Ialongo, Poduska, and Kellam	2003	Evaluation Study of Universal Preventive Interventions in Baltimore City (n = 297)	6–19/20	White Non-White	Males	Teacher ratings	4	Aggression; Also, focused on impact of trajectories on later adult outcomes

Author	Year	Sample	Age	Race	Sex	Outcome measure	Number of groups	Notes
Sampson and Laub	2003	Boston-area delinquents (n = 500)	7–70	White	Male	Arrests	6 for total arrests; 5 for violent and alcohol/drug arrests	Longest longitudinal dataset in the world
Shaw et al.	2003	Allegheny County Women's, Infants, and Children Program in Pittsburgh (n = 284)	2–8	White, black, other	Males	Parent reports of child adjustment problems	4	
Nagin et al.	2003	Montreal Longitudinal Study (n = 1,037)	10–15	Whites	Males	Teacher ratings of physical aggression, inattention, prosocial behaviorsSelf-reports of violence	4	Examined effect of grade retention on life-course dynamics
Wiesner and Silbereisen	2003	German adolescents (n = 318)	11–17	White	Males Females	Self-reports of delinquency	4	They found that time-averaged covariates distinguished between trajectory groups better than initial covariates. For example, academic achievement was significant in the time-averaged manner but not in the initial rating approach.

Appendix (continued)

Authors	Year	Sample	Age	Race	Gender	Outcome Variable	Number of Groups	Interesting finding
Oesterle et al.	2004	Seattle public school students (SSDP)	13–18	White, asian, black, other	Males Females	Self-reports of heavy drinking	4	Used heavy drinking trajectories to predict health status and behavior at age 24
Eggleston et al.	2004	Boston-area delinquents (n = 500)	7–70	White	Male	Arrests	6 for total arrests, different numbers for other analyses	Methodological piece showing different trajectories depending on death, follow-up, and incarceration
NICHD	2004	NICHD Study of Early Child Care (10 US Cities, n = 1,195)	2–9	White Non-White	Males Females	Mother ratings	5	Aggression
Orlando, Tucker, Ellickson, and Klein	2004	Rand Adolescent & Young Adult Panel Study (n = 5,914)	13–23	White Non-White	Male Female	Self-reports	6	Smoking (quantity and frequency)
Tremblay et al.	2004	Quebec families with a five-month old newborn (n = 572 families)	17–42 months	White	Males Females	Mother ratings of physical aggression at 17, 30, and 42 months after birth	3	

	Year	Study	Age	Race	Gender	Data source	Groups	Notes
Hix-Small, Duncan, Duncan, and Okut	2004	National Youth Survey (n = 698)	11–17 (T1)3 waves	White Non-White	Males Females	Self-reports	7 alcohol use7 marijuana use	Marijuana use
Ellickson et al.	2004	Rand Adolescent/Young Adult Panel Study (n = 5,833)	13–23	White Non-White	Males Females	Self-reports	4 (abstainers defined a *priori*, 5 total)	
Francis et al.	2004	1953 Home Office Offenders Index Birth Cohort (n = 11,402)	Birth-40	White	Males Females	Convictions	9 males; 3 females	Examined in different age bands
Chassin, Flora, and King	2004	Longitudinal Study of Binge Drinking (n = 454)	11–30	White Non-White	Males Females	Self-reports	3 consumption (abstainers defined a priori, 4 total); 3 dependence (persistent and no-diagnosis groups defined a priori, 5 total)	Alcohol and illegal drug use and dependence
Weisburd et al.	2004	Seattle, WA street segments (n = 1,544,604)	1989–2002	N/A	N/A	Incident reports	18 (8 stable, 3 increasing, 7 decreasing)	One of the few studies to examine trajectories at the macro level

Appendix (continued)

Authors	Year	Sample	Age	Race	Gender	Outcome Variable	Number of Groups	Interesting finding
Griffiths and Chavez	2004	Chicago, IL homicide file (n = 831 census tracts)	1980–1995	N/A	N/A	Homicide reports	3 (total homicide rate); 2 (street gun homicide rate); 3 (other weapon homicide rate)	One of the few studies to examine trajectories at the macro level
Hamil-Luker et al.	2004	National Longitudinal Survey of Youth (NLSY) 1979 (n = 2,509)	14–16 through 33–35	White Non-White	Males Females	Self-reports	4 adolescence. Then, among delinquents, partiers, and troublemakers, 3 groups emerged in adulthood; among conformists, 2 groups emerged in adulthood	Diversity in early adulthood cocaine use within groups
Wiesner and Windle	2004	Middle Adolescent Vulnerability Study (n = 1,218)	15.5–17	Whites Non-Whites	Males Females	Self-reports	6	
Bongers, Koot, van der Ende, and Verhulst	2004	Zuid-Holland Longitudinal Study (n = 2,600 – 2,076)	4–16	Whites	Males Females	Parent-reports of CBCL	3 aggression; 4 property viol; 4 status viol; 6 opposition	Males and females had same shape, but male rates were higher than females

Séguin, Assaad, Nagin, and Tremblay	2004	Montreal Longitudinal Study (n = 303)	6–22	Whites	Males	Self-reports	4 aggression; 4 hyperactivity	Relate cognitive-neuro-psychological function to trajectories of aggression and hyperactivity
Piquero et al.	2005	1972 Dunedin Multidisciplinary Health and Human Development Study (n = 1,000)	13–17 18–26	Whites	Males Females	Convictions	3 for males, 2 for females	Use adolescent groups to predict adult conviction frequencies. Results replicate across gender.
Brame, Bushway, Paternoster, and Thornberry	2005	RYDS (n = 727)	11–15 (T1) 15.5–19.5 (T9)	White Non-White	Males	Self-reports Official Arrest Records	2	Violent & Non-Violent Offending
Piquero et al.	2005	Research on the Pathways to Desistance (n = 1,355)	14–18 (T1) 15.5–19.5 (T4) (every 6 months)	White Non-White	Male Female	Self-reports	4 legal cynicism; 5 legitimacy	First to investigate trajectories of perceptions of legal socialization

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Appendix (continued)

Authors	Year	Sample	Age	Race	Gender	Outcome Variable	Number of Groups	Interesting finding
Shaw et al.	2005	Women, Infants, and Children (WIC) Nutritional Supplement Program in Pittsburgh (n = 284)	1.5–10	White Non-White	Males	Parent reports-conduct problems and Teacher reports-hyperactivity	4	Investigated separate and co-occurring trajectories
Hynes and Clarkberg	2005	National Longitudinal Survey of Youth 1979 (n = 2,093)	14–21 1979 33–40 1998	White Non-White	Females	Self-reports of employment	6	First paper to examine employment trajectories
Abroms, Simons-Morton, Haynie, and Chen	2005	Going Places Problem Behavior Prevention Program (Maryland, n = 1,320)	6th grade – 9th grade	White Non-White	Males Females	Self-reports of cigarette smoking	5	
Stoolmiller et al.	2005	Oregon Youth Study (n = 206)	15–24	White Non-White	Males	Self-reports of depression	4	First paper to examine depression trajectories
Blokland et al.	2005	Criminal Career and Life-Course (CCLS) Study (n = 5,164)	12–72	Whites	Males Females	Official Conviction RecordsSelf-reports	4	Small group of high-rate persisters exhibits relatively high and flat trajectory through age 72

Jackson, Sher, and Schulenberg	2005	Monitoring the Future (n = 21,177 / 15,162)	18–20 /24–26	White Non-White	Male Female	Self-reports	4 alcohol use; 5 cigarette smoking; 7 dual trajectory	
Jacob, Bucholz, Sartor, Howell, and Wood	2005	Vietnam Era Twin (VET) Registry (n = 330)	<21–40	White Non-White	Males	Self-reports	4 alcohol use	
Windle, Mun, and Windle	2005	Lives Across Time (LTA, n = 760)	16–25	White Non-White	Male Female	Self-reports heavy drinking	4 males; 5 females	
Hamil-Luker	2005	1979 National Longitudinal Survey of Youth (n = 754)	19–27 /33–41	White Non-White	Female	Self-reports	4	First paper to examine trajectories of public assistance receipt
Blokland and Nieuwbeerta	2005	Criminal Career and Life-Course (CCLS) Study (n = 5,164)	12–72	Whites	Males Females	Official Conviction RecordsSelf-reports	4	Links life circumstances to offense trajectories
Tucker et al.	2005	Rand Adolescent/Young Adult Panel Study (n = 5,914 smoking; n = 5,694 binge-drinking, n = 5,833 marijuana use)	13–23	White Non-White	Males Females	Self-reports	5 (smoking); 4 (binge drinking); 4 (marijuana use)	Smoking, binge drinking, and marijuana use trajectories

Appendix (continued)

Authors	Year	Sample	Age	Race	Gender	Outcome Variable	Number of Groups	Interesting finding
Marshall	2005	1984 South Australia Birth Cohort (n = 3,343 persons with at least one police apprehension between ages 10–17)	10–20	White Non-White	Males Females	Official Police Apprehension	6	Very-high chronic group (n = 25, 1% of the sample), 88% male, 48% indigenous, average of 37 events and average age of 11 at first event
Ezell and Cohen	2005	California Youth Authority Parolees 1981 and 1982 (n = 1,989) 1986 and 1987 (n = 1,443) 1991 and 1992 (n = 1,434)	1981 and 1982 (ages 7–37) 1986 and 1987 (ages 7–33) 1991 and 1992 (ages 7–27)	Whites Non-Whites	Males Females (but analysis limited to males)	Official Arrest Records	6	6 trajectories emerged for each of the three CYA parolee release cohorts
Moffitt	2006	1972 Dunedin Multidisciplinary Health and Human Development Study (n = 525 males)	7–26	Whites	Males	Self-, Mother-, and Teacher-reports	5	Examined conduct disorder symptoms from ages 7 to 26
Piquero and Piquero	2006	Business Software Alliance Global Software Piracy Study (n = 87)	1995–2000	Countries	N/A	Software-shipments Software-pirated	6	Examines software piracy trajectories