# The Criminological Puzzle

**Thomas K. Arnold**

The Criminological Puzzle – Version 8


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Thomas K. Arnold
1009 Burns Av.
Cincinnati OH 45230
(320) 252-4993
arnoldtk@mail.uc.edu

# Contents

# Abstract

Criminal behavior is a puzzling phenomenon. Criminologists have been trying to find the causes of crime and criminal behavior for several hundred years. This process appears to be analogous to working on a "criminological puzzle." The analogy of a criminological puzzle is being used for a number of reasons. First, criminologists have amassed thousands of separate pieces of information about crime and criminal behavior, and trying to aggregate these pieces could be compared to trying to assemble a huge picture puzzle. Second, there appear to be a number of mini-puzzles that have turned up in the form of statistical regularities, conundrums, and paradoxes. Third, it is suggested that the current set of standard scientific models are inadequate and that new scientific approaches should be tried. Finally, it is suggested that the pieces of the puzzle are curved, and fit together precisely. The process of trying to understand crime and criminal behavior is analogous to trying different methods to solve a puzzle. Several suggestions will be made that could lead toward more rapid progress in solving the criminological puzzle. The first suggestion is that criminologists find pairs of variables that fit together. For example, it will be suggested that crime rates are a function of the propensity to commit crimes and the propensity of societies to sanction behavior. The propensity to commit crimes is massively multivariate and complex. The limiting processes involved ensure that propensity is normally distributed in the population. The complex processes involved ensure that propensity is constantly fluctuating. In order to understand the processes involved in creating criminal behavior, criminologists must spend more time looking at the nonlinear dynamics of crime and criminal propensity. A dynamic is a pattern of change. There are a set of three nonlinear dynamic models that will be proposed as necessary for solving the criminological puzzle. First, it will be suggested that the dynamics of crime rates are a nonlinear sigmoid normal function resulting from the interaction between the propensity of individuals to harm others and the propensity for groups to sanction perceived harms. Second, it will be proposed that the dynamics of the age-crime curve are due to a lag in the developmental timing of two nonlinear trajectories, the life course trajectories of physical and mental capacity. Third, it will be proposed that individual levels of criminal propensity have nonlinear dynamics governed by complex and chaotic processes in the human brain. These three nonlinear dynamics provide possible solutions to many of the criminological conundrums and paradoxes.

# Preface

The following book is incomplete at this point, and it should be considered a work in progress. Future versions should be forthcoming, and you may want to stop back to the criminological puzzle web site from time to time if you are interested in a more complete treatment of these topics. I recognize a need to go through and start inserting references in appropriate places.

It may help if I give a little history behind this project.

I have been an amateur psychologist since I was in the army in 1975. I was suffering from depression and started reading books on psychology and self-help. I was caught up in the idea that all I needed to do was think differently and my problems would go away. The problem was that no matter how hard I tried, it seemed that my problems kept coming back. I had decided to develop a "quick change" method, but failed miserably. After about 20 years of effort, I found that I had changed, but this process was anything but quick. The process was one of ups and downs that gradually were further up than down.

In 2002, I decided to try to see if I could help the inmates at the local jail. I joined a restorative justice circle and spent the next eight years listening to offenders describe their issues. Again, I noticed that the process of change seemed to be anything but quick. Offenders typically returned two or three times before not coming back. Some kept coming for eight years in a row.

In 2004, I had decided that I needed to abandon the amateur psychology and learn professional psychology. I went back to school to become a therapist. I began studying family systems therapy at the local university and eventually graduated with a master's degree in criminal justice counseling. My goal was to try to understand how and why criminal offender's change so that I could try to help them turn their lives around.

The measurement of offender change was the basis behind my Master's thesis (Arnold, 2007). My master's thesis involved an examination of risk assessment scores collected with the Level of Service Inventory Revised (LSI-R; Andrews & Bonta, 1995). The LSI-R risk assessments were conducted over several years at approximately seven month intervals. Andrews and Bonta (2006) had suggested that the LSI-R had "dynamic predictive validity," which meant that it could be used to assess changes in offender risk levels over time. The evidence supporting the LSI-R's ability to measure change was that predictive validity improved from the first to the second assessment (Andrews & Robinson, 1984). The hypothesis put forward by Andrews and Bonta (2006) was that offender risk levels were changing between assessments and predictive validity improved because the second LSI-R was capturing the changes in offender risk levels between assessments.

In my Master's thesis (Arnold, 2007), I demonstrated that the predictive validity improved from the first to the second LSI-R assessment, but not from the second to the third assessment, or from the third to the fourth assessment. This seemed to be an important finding because it challenged the proposition that the LSI-R could be used to assess change. There were two possibilities. 1) The LSI-R was not a good measure of change. 2) Offender risk levels weren't changing.

I hesitated to publish this work since I could not explain the findings. I did not want to make the case that offenders were not changing. I began to try to figure out what was happening.

I was fortunate to find Ross MacMillan, a professor at the University of Minnesota who was in charge of the Life Couse Center. Dr. MacMillan helped me analyze the LSI-R data. I spent an entire year studying life-course criminology and working with my LSI-R dataset to try to figure out what was going on.

During that time, I wrote a working paper on the nonlinear dynamics of criminal behavior (Arnold, 2008). The problem that I was trying to understand was why there seemed to be changes in risk in the short term, but little change in risk in the long term. Again, I was seeing the fluctuation that I had experienced in my own life and in the offenders I was seeing at the jail. Using individual growth curve modeling, I found that offender recidivism risk levels fluctuate in almost random patterns that are very difficult to predict. The aggregate pattern was a slow decline in group level risk over time. This slow decline in aggregate risk seemed to be explainable by the age crime curve (Farrington, 1986).

In 2010, I decided to pursue a doctoral degree in Criminology and Criminal Justice at the University of Cincinnati. I wanted to explore the issues related to offender assessment and the age crime curve. This was a very productive move.

One of the more important facts that I learned was that here are a lot of theories about why people commit crimes. Each of these theories appears to have empirical support and so it is difficult to prove them false. This seemed to be a problem. On the other hand, in the field of offender risk assessment, the number of theories was not an issue. Risk assessment instruments routinely assess ten or more risk domains with no problem. There seemed to be a disagreement between theory and practice.

My work on the age crime curve proved to be more fruitful. I had been trying to explain the sudden shift in direction in the crime rate at about age 18. This shift did not seem to be developmental. How could something in human behavior shift so rapidly? It couldn't. There must be some type of combination of intersecting developmental trajectories behind this shift. Tremblay's work on aggression over the life course seemed to provide a clue. He demonstrated that the frequency of aggressive acts was declining for most people from a young age. However, the frequency of aggressive crimes was increasing. What could explain this? The only thing that made sense was some type of intersecting trajectory model involving physical and mental developmental trajectories.

I was doodling some developmental trajectories while sitting in a hostel dorm room at the American Society of Criminology conference when a roommate said, "That is the income by age curve." Apparently, income rises to a peak at about age 35 and falls thereafter. As I studied this growth model, I started playing with different types of developmental trajectory models and trying to fit the models to the National Incident Based Reporting System (NIBRS) age crime curve data. I was having difficulty fitting the models because the trajectory of crime from 0-18 was curved and all of my developmental models were straight lines from 0-18. I tried to envision what was happening, and came up with the idea of a shifting normal distribution with a threshold. If the propensity for crime was normal, and shifted the same amount each year, the crime rate should be the area under the curve to the right of a threshold. When I fit this model to the data, I found that I was able to explain 99.995% of the variance in the age crime curve from 0-18. This seemed to be something real.

A number of breakthroughs followed. The first occurred when I showed this to Donatello Telesca, a microbiologist. He pointed out that I was using a "the method of probits," which was used in the analysis of germ kill rates in the presence of antiseptics. As I started reading the microbiological literature, it became clear that the same mechanisms that create sigmoid germ kill rates were causing sigmoid crime rates in the age crime curve. An article by Brooks (1918) spelled this process out quite simply. If there is a bell shaped distribution with a threshold, changing the threshold level will create a sigmoid response curve. Further investigation of this phenomenon, along with a study of normal distributions, began to shed light on the other problem of too many criminological theories. The central limit theorem stated that when many variables are added together, they create a normal distribution.

The next breakthrough was finding that most of this work had been done before. Quetelet (1833) had proposed a developmental lag model involving strength, passion, and reason. However, no one seemed to have ever cited this model. Quetelet (1848, 1869) had proposed that criminal propensity followed the "law of accidental errors," which is a way of saying that criminal propensity was normally distributed. I found one citation that indicated people were reading this material. I then found the multiple factor work from the early 1900s. The multiple factor theorists had suggested that criminal propensity is caused by many risk factors acting together. This idea was dismissed as the "abdignation of theory" (Short, 1970). In essence, the theories needed to solve the age crime curve problem had either been ignored or dismissed.

The realization that most of what I had been working on had already been proposed over one hundred years ago was sobering. Why would anyone listen to my ideas if people wouldn't listen to theirs? There seemed to be a problem here. As I talked with various people about my ideas, a comment by a coworker stood out "There seem to be a lot of moving parts." This seemed to be a real problem. People don't seem to like "lots of moving parts." It seemed that if I was to find any level of acceptance for my theories, I would need to deal with one part at a time.

Another issue seemed to be the lack of methods for working with normal distributions. Rowe, Osgood, and Nicewander (1990) had written a very nice article on the possibility that criminal propensity was normally distributed, but it did not seem that their work was ever replicated. It appeared that they had used a custom software program, and the lack of software might be a barrier to moving forward. The methods problem seemed to be an issue that would need to be overcome.

Finally, another coworker had suggested that this work is highly theoretical. It seemed that practical works are more likely to be accepted. As I looked over my work, the issue of incapacitation seemed to be appropriate. The normal threshold model predicts that incapacitation should have rapidly diminishing returns. This seems to be a multi-billion dollar problem that these theories could help address.

The problem was that I had amassed a literal mountain of articles, statistical calculations, data sets, and theories. How could this be organized? I considered writing individual articles, but without some coherent framework, these seemed incomplete. I decided to begin the process of putting these ideas out as a web site called the criminological puzzle (http://www.thecriminologicalpuzzle.com). This book is an extension of the website and provides a comprehensive overview of these ideas. I hope to follow this up with a number of journal articles that focus on individual topics.

This is a work in progress and I am hoping to generate some interest in my ideas. I am hoping for some constructive criticism. If some part of this work does not seem clear, please let me know. My email address is arnoldtk@mail.uc.edu. Of course, I am also hoping that you can use this in your own work. Citations are welcome. Thanks in advance for any consideration you can provide.

I wish you all the best,

Tom Arnold

# The Criminological Puzzle

## Section 1: Introduction

# Chapter 1: Introduction

Crime and criminal behavior are a part of human existence that have been documented as far back as humans have kept records.  Crimes are individual acts that are perceived by society to be harmful enough to warrant legal sanctions.  For the past several hundred years, criminologists have been trying to find the causes of crime with the hope that the amount of harm caused by individuals can be reduced.  This process has produced a cornucopia of information about crime and criminal behavior.  While this huge amount of information could be considered a blessing, there is a need to make sense of all of these disparate facts.  Criminologists have been trying to fit this information together into a coherent picture that explains the observed phenomena.   In a sense, this process could be considered to be similar to the process of fitting a puzzle together.  This puzzle will be referred to as "the criminological puzzle."

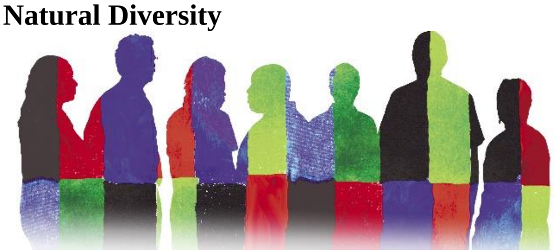
Efforts to find the solution to the criminological puzzle appear to have been impeded by a desire to find an overly simple solution.  It seems that the solution to the criminological puzzle may be more complex than has been previously envisioned.  The complexity involved in creating a solution to the criminological puzzle creates a need for a very logical and systematic approach.  This book represents an initial attempt to provide method for creating a logical and systematic solution to the criminological puzzle.

The initial comment from people who have seen this work has been that "there seem to be a lot of moving parts."  This certainly would seem to be an apt description of this work.  An attempt will be made to show how several moving pieces fit together.

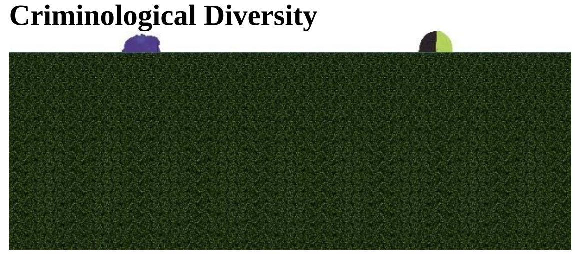
## Recognizing the Difficulties in Studying Crime

Before continuing, it is important to recognize the difficulties in studying crime.  Notice the picture on the left.  There is a natural diversity in the types of people.  The criminologist however, only sees a fraction of the people, since only a few people commit crimes.  This creates a problem when trying to understand criminal behavior.  (Note: Thanks to the National Human Research Group for the graphic. https://www.genome.gov/dmd/index.cfm?node=Photos/Graphics).

**Natural Diversity**



**Criminological Diversity**



## Theory, Method, and Practice

There are three interlocking areas that will be addressed. These interlocking areas address theory, method and practice.  These three areas are highly inter-related.  One cannot address the types of theories presented without developing new methods, and these methods directly relate to practice.

### *Theory*

The first area that will be addressed is theory.  The theories presented in this book move beyond the traditional type of criminological theory.  Traditional criminological theories are "ceteris paribus" theories.  They take the form "all other things being equal, crime is caused by X."  Replace X with some cause. For example, Gottfredson and Hirschi (1990) make the case that crime is caused by low self-control, or not thinking about the future (Hirschi, 2004). A theory that low self-control causes crime is a ceteris paribus theory.

Ceteris paribus theories can be considered to be "micro" theories. A ceteris paribus theory looks at individual causes of crime or small sets of integrated individual causes. Some of the theories presented in this book are "macro" theories. The purpose of a macro theory is to explain overall statistical regularities. Another term that could be used to describe these macro theories is "aggregate" theories. An aggregate theory is intended to explain statistical regularities at the population level rather than the individual level.

Some aggregate theories that will be addressed include the multiple factor theory, the propensity/sanctioning theory, the normal propensity theory, the asymmetric selection theory, the sigmoid crime theory, and the chaotic brain theory. A new type of ceteris paribus theory called the "capacity" theory will also be developed. Taken together, these new theories provide a different way of looking at the nature of crime and criminal behavior.

## Three Problematic Theoretical Practices

There are three problematic practices in criminology that should be abandoned. The three problematic practices are 1) trying to turn risk factors into a general theory of crime, 2) the career criminal model, and 3) the criminal career model.

### *Trying to Turn Risk Factors into a General Theory of Crime*

Much of the effort in criminology has been spent trying to turn risk factors into a general theory of crime. These attempts have continued for 140 years and each attempt has ended in failure (cf. Lombroso, 1876; Lombroso, 1910). It is time to change the approach.

The basic premise behind the general theory of crime model is that there can only be one reason for criminal behavior. The proponents of this model suggest that different theories have different theoretical premises that are incompatible. The controlling logic behind the general theory worldview is "OR." In the general theory worldview, crime is caused by lack of control OR strain OR learned behaviors. The proponents of this model suggest that there must be some sort of theoretical competition to determine which of the various theories of crime is "true."

An alternative to the general theory of crime model is the theoretical aggregation model. The controlling logic behind a theoretical aggregation model is "AND." In an aggregate worldview, crime is caused by lack of control AND strain AND learned behavior.

### *The Career Criminal Model*

The career criminal model provides an attempt to create an offender taxonomy. The basis behind the offender taxonomy is that there are separate groups of people with varying degrees of criminality. The placement into these groups can be done through some selection mechanism. The task set for criminologists is to determine some method for determining the membership criteria and the crime rates for various groups such as "career criminals," "non-career criminals," and "non-criminals."

An alternative to the offender taxonomy is the continuous normal model. In a continuous normal model, the degree of criminal propensity is continuously distributed in the population. There are no groups in the continuous normal model, simply varying degrees of criminality.

It will be suggested that offender taxonomies are not empirically supportable. The reason that offender taxonomies such as the career criminal model breaks down is that criminal propensity is a continuous normal property of humans. It is important to look at the predictions from offender taxonomies and continuous models and decide which model most accurately reflects reality.

*A Brief History*

The interest in career criminals began in earnest when a report by Thorsten, Figlio, and Sellin (1972) indicated that a small group of people tend to commit a large proportion of the crimes. A mathematical model was developed that posited that each offender had a crime rate which was represented by the Greek letter alpha (λ).

> Most significantly, λ varies considerably across offenders so that the distribution of λ is highly skewed: the median offender commits only a handful of crimes per year, while a small percentage of offenders commit more than 100 crimes per year. This finding is obviously especially important in developing policies to reduce crime by concentrating on highrate offenders, or "career criminals." (Blumstein et al., p. 4)

*Imagining a Continuous Normal Model of Criminal Propensity*

The problem with the career criminal taxonomy is that the predictions only work if there actually is a taxonomy. The predictions do not make sense if the distribution of criminal propensity is continuous normal. To illustrate this, a thought experiment will be created.

Imagine a world where height is used to sanction people instead of harmful behavior. In this height averse society, the mean height is 69 inches (5’ 9”) with a standard deviation of 3 inches. The legislature has decided that it is a crime to be over three standard deviation higher than the mean. Therefore, anyone over 78 inches (6’ 6”) is subject to legal sanctions for being too tall.

There is a group of criminologists, which will be called the “taxonomists,” who are working to estimate the height reduction in society from locking up as many tall people as possible. They determine that there are

## *The Criminal Career Trajectory*

The criminal career trajectory is a model developed to study the career criminal. The concept involves developing a simple model of onset, persistence, and desistance. This model is shown below (Blumstein et al., p. 21). The problem with this model is that the individual crime rate is assumed to be relatively constant during the period that a person is committing crimes. This model does not tend to reflect reality.

**Criminal Career Model from Blumstein et al., p. 21**

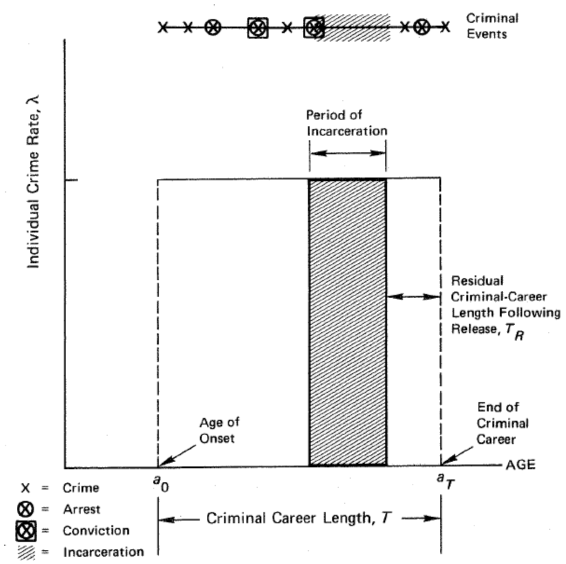



**FIGURE 1-1** An individual criminal career.

## Theoretical Alternatives

The discussions presented in this book include a set of theoretical models that provide alternatives to the three false models. The models presented include an aggregated theory of crime model to replace the general theory model, a continuous propensity model to replace the career criminal taxonomy model, and a complex trajectory model to replace the criminal career trajectory model.

### *An Aggregated Theory of Crime (A.K.A. Multiple Factor Theory)*

An aggregated theory of crime proposes that crimes are the result of numerous factors that span theoretical orientations. This theory was originally called the multiple factor theory.

### *A Continuous Propensity Model*

A continuous propensity model is based upon the assumption that criminal propensity is a continuous trait that is normally distributed.

### *A Complex Trajectory Model*

A complex trajectory model is based upon the assumption that the trajectory of criminal behavior is a complex trajectory that is a function of development and complex cognitive processes.

# *Method*

One of the barriers to working with aggregate theories is a lack of appropriate methods. For example, several theorists have suggested that criminal propensity is normal, but there have not been adequate methods for modeling normal phenomena. Some methods from germ science will be adapted for use with normal criminological data. The reader is encouraged to speculate about what germs and criminals may have in common.

A number of methods for working with aggregate and individual data will be explored including quantile transforms, curve fitting in Python and Excel, and individual growth curve modeling. It is hoped that these new methods can help criminologists deal with some of the complexities of dealing with complex data sets.

### The Three Nonlinear Dynamics Needed to Explain the Age Crime Curve

There are three essential nonlinear dynamics needed to explain the age crime curve, which is, by itself, a fourth nonlinear dynamic. Before beginning a discussion of nonlinear dynamics, it would seem important to define the concept of dynamics. Something is “dynamic” if it is subject to change. The term “dynamic” can also refer to a “pattern of change.” Nonlinear dynamics refers to patterns of change that are curved, or “nonlinear.” A nonlinear dynamic occurs when a change in one or more variables causes a nonlinear change in one or more other variables. There are three different types of nonlinear dynamics involved in creating the age crime curve.

In order to build a model of the age crime curve, one must understand three different nonlinear dynamics. The first essential nonlinear dynamic that must be understood is the sigmoid normal relationship between changes in the propensity for crime, the societal sanctioning process, and crime rates. The second nonlinear dynamic that must be understood is the developmental dynamics of strength, mental capacity, and criminal propensity over the life course. The third nonlinear dynamics that must be understood are the chaotic nonlinear dynamics of intra-individual variability in criminal propensity over time. These three nonlinear dynamics create the fourth type of nonlinear dynamic which is the age crime curve.

## *Practice*

The main practice areas for the theories and methods presented is in this book are related to comparative criminology and population models of propensity and sanctioning. In order to compare levels of propensity and sanctioning between groups, theories and methods are needed to deal with the unknown effects of propensity and sanctioning.

These theories and methods will be particularly relevant to incapacitation models. Policy makers need models that will enable them to predict the effects of increases in incarceration levels. The theories and methods provided in this book can be used to estimate the effects of increases in incarceration.

## Lombroso’s Dilemma

Fitting these three nonlinear dynamics together to model a fourth nonlinear dynamic is not easy. It will be suggested that a systematic step by step approach is needed. This idea seems to be best captured by Lombroso in a statement that will be called “Lombroso’s Dilemma.

Lombroso recognized that crimes were complex phenomena, but he also recognized the need to study causes, one at a time. Lombroso (1899/1911; p. 1) noted that “EVERY crime has its origin in a multiplicity of causes, often intertwined and confused, each of which we must, in obedience to the necessities of thought and speech, investigate singly.”

This statement expresses “Lombroso’s Dilemma.” Lombroso’s Dilemma is that crimes are multifaceted and complex phenomena, but we can only think about one concept at a time. Simply put, our brains are limited and can only focus on one thing at a time. We need to consider each piece of the criminological puzzle individually before putting pieces together. Then, we can try to fit two together. Once we have two pieces put together, we can try to add a third, and then a fourth. It is almost conceptually impossible to do more.

### *The Need for a Complex Model*

It may initially seem that this process is overly complex. It is much simpler to work on individual theories of crime. However, the processes creating crime and criminal behavior are complex. There is a certain amount of complexity that is unavoidable.

For example, there are three essential nonlinear dynamics that must be taken into account if criminologists want to understand the age crime curve. A full understanding of the processes involved requires the use of these three nonlinear dynamics. In order to get to the point where the separate models can be put together, each of these models needs to be examined individually.

#### Importance

This work seems to be important. There seem to be several innovative theoretical, methodological, and practical discoveries, along with a number of rediscoveries. This work should be of interest to anyone working on biological correlates of crime including genetic and developmental life-course theorists. Comparative criminologists and policy analysts should be interested in the propensity/sanctioning models presented. In particular, policy analysts may want to look at expected utility of sanctioning as a method for reducing propensity levels in the population. The models suggest that the current levels of incarceration in the US are highly inefficient. Finally, psychometricians may want to consider the material on intra-individual variability.

### *The Need for a Step by Step Approach*

The concept of a criminological puzzle will be used to try to show how these various pieces fit together. When solving a puzzle, it is important to look carefully at each piece of the puzzle, and then try to fit the pieces together. The process used in this book will be similar. While this may initially seem to be more work than is needed, the effort would seem to be worthwhile. Just as a picture puzzle is put together, one piece at a time, the criminological puzzle will have to be fit together, one piece at a time.

## Why is Crime a Puzzle?

There are a number of reasons that the term “criminological puzzle” seems appropriate.

1. There are many pieces
2. Puzzle solving skills are needed to fit the pieces together
3. Some of the pieces have unique curves
4. The curved pieces can be fit together exactly
5. Sometimes, it helps to flip the pieces
6. Some pieces were buried in the pile

### *The Criminological Puzzle has Many Pieces*

The history of criminology has been one of almost constant discovery. Hundreds and possibly thousands of various factors have been found that are correlated with an increased likelihood of criminal behavior. The correlates of crime and criminal behavior can be chemical, biological, psychological, sociological, ecological, and environmental. Piecing this information together is more challenging than fitting the most complex picture puzzle together.

### *Puzzle Solving Skills Are Needed*

The skills needed to solve the criminological puzzle would seem to be similar to those needed to put a large picture puzzle together. There are a number of skills that make solving puzzles easier. Solving a puzzle requires the ability to see the big picture. There is a need to see the patterns that fit together in unique and complex ways. On starts by laying out the pieces, setting aside the edge pieces, and finding transition pieces. Then a systematic step by step approach is used to fit pairs together and then larger sections.

### *The Pieces are Curved*

There appear to be several curved pieces to the criminological puzzle. These curves will be referred to as nonlinear dynamics. Several different types of nonlinear dynamics will be explored. The first nonlinear dynamic is the sigmoid curve that crime rates follow with changes in propensity or sanctioning. The second nonlinear dynamic will be developmental trajectories. The third nonlinear dynamic involves the chaotic curves found in the trajectories of criminal propensity over time. These curved pieces are almost as unique in shape as those found on any picture puzzle.

### *The Curved Pieces Fit Together Precisely*

In a picture puzzle, the pieces fit together perfectly and no two pieces are the same. One of the more interesting features of the criminological puzzle is how the curves pieces seem to fit together almost exactly. It would appear that the age crime curve is the result of three nonlinear dynamics that fit together in a precise way. The fit would appear to be as tight as that found in any picture puzzle.

### *Sometimes, It Helps to Flip the Pieces*

Sometimes, it helps to flip the puzzle pieces and see how they might fit when they are turned around. One cannot make assumptions about which direction a piece should face. The puzzle solving process often involves a substantial amount of trial and error. It will be suggested that criminologists may need to flip the pieces in order to put the age crime curve dynamics together.

### *Some Pieces Were Buried in the Pile*

It seems that some of the pieces to the criminological puzzle were buried in the pile. Probably 80% of the solutions explored in this book were proposed long ago. Why were these solutions overlooked? These solutions are like pieces of a puzzle buried in the pile. It would seem that some effort should be made to dig these pieces out and find a place for them.

## Looking Ahead

Several models will be proposed that appear to depart from the current thinking about crime and criminal behavior. These models represent theoretical, methodological, and practical innovations. It seems that some of these models might require a substantial shift in the way that criminologists view crime and criminal behavior. The magnitude of the shift in thinking to bring the entire set of models into focus is compounded by trying to fit several innovative models together at once.

There are three basic mathematical models that will be addressed. These models involve three separate types of interactive bivariate processes that are completely interrelated. The bivariate processes involve three separate types of nonlinear dynamics.

1) The nonlinear sigmoid relationship between propensity, sanctioning, and crime rates.

2) The nonlinear developmental interactions that affect the life-course propensity for harm
3) The nonlinear patterns in the intra-individual variability of the propensity for harm

The conceptual skills needed to work with these three nonlinear models are all different. In order to understand the nonlinear dynamics of crime rates, one has to learn to "think normally." In order to understand the nonlinear dynamics of development, one has to think about growth and decline and how developmental timing affects behavior. In order to understand the nonlinear dynamics of the propensity to harm, one has to consider the chaotic processes involved in brain function.

The importance of these models becomes apparent when considering the impact of incarceration. One of the more popular models of the effects of incarceration on crime rates is the career criminal model. This model assumes that there are groups of offenders with different rates of offending and life-course trajectories. An examination of the models presented as partial solutions to the criminological puzzle suggests that there are several flaws with the career criminal model. The nonlinear dynamics of propensity, sanctioning, and crime rates suggest that incapacitation efforts have rapidly diminishing returns. The developmental and intra-individual variability models suggest that criminal propensity is fluctuating due to developmental factors and brain function, and that a steady state model of criminal behavior cannot be defended.

This is a lot of material to cover. Any one of these models will take time to digest. The inter-relatedness of the concepts suggests that a linear approach to trying to master these concepts will probably not work very well. There is a need for iteration. Therefore, after a brief discussion of some definitions, there will be a complete list all of the bivariate relationships that will be addressed. This will be followed by a pictorial survey of some of the proposed models.

You will probably want to use a process of overview, inview, and review. There is a web site at http://thecriminologicalpuzzle.com to facilitate the learning process. You may want to preview these and try some exercises after you have a chance to look over the general model.

## Definitions

It is important to understand the terms that will be used. Some of these terms may be used in a different context than you may be used to. Some of the definitions for the more important concepts are presented here, in order to insure that the meanings are clear.

### *Crime*

Crime is defined as "individual actions that are perceived by society to be harmful enough to warrant legal sanctions." This definition has several pieces. Crimes occur at the intersection between the individual and society. Crimes are "individual actions" that are "perceived" to be harmful. Crimes cannot occur without both an individual's action and a reaction by society. The "society" is the group in which a person lives. The behaviors classified as "crimes" vary by society.

### *Propensity*

Propensity is short for "criminal propensity." Propensity will be defined as "the likelihood that a person will act in a way that is perceived to be harmful enough to warrant legal sanctions." In general, propensity is correlated with two factors. The first factor is the likelihood that a person will harm themselves or someone else. The second factor is the likelihood that a person will ignore the possibility of sanctions. Propensity = *f*[Harm, Ignoring Sanctions].

The first factor is a function of willingness and capacity. Harm requires both a willingness to harm oneself or others and the capacity to do so. The lack of the physical capacity of young children to seriously harm others is a major factor in the age crime curve.

The second factor is related to control. Control factors include social and personal. Personal control is often referred to as low self-control and is correlated with a lack of forethought. Crimes tend to be poor choices and propensity is correlated with a tendency to not consider the possibility that the actions will have potentially serious consequences (cf. Hirschi, 2004).

### *Sanctioning*

Sanctioning will refer to the societal act of imposing legal consequences upon individual actions perceived to be sufficiently harmful to warrant such sanctions. Sanctions are imposed because the people in charge of a particular society believe that an individual's behavior is harmful enough to warrant legal prohibitions. The sanctioning process is somewhat subjective and varies by society.

### *Crime Rates*

A crime rate is the number of crimes per unit person in some unit of time. If X crimes are committed by N people in one year, the crime rate is X/N. For the purposes of the discussions that follow, the time period used will be one year. A crime rate could be considered to be the probability that an individual will commit a crime. One of the issues regarding probabilities is replacement. In the case of crime rates, the replacement rate depends upon capture rates and incarceration levels. These issues have less importance as the size of the sample increases. Therefore, population crime rates can be considered to be the probability that an individual will commit a crime in some unit of time.

### *Dynamics*

The term "dynamics" refers to "patterns of change." There is quite a bit of interest in the criminal justice community in demonstrating that the propensity for criminal behavior is "dynamic" and capable of change, but there has been less work on the dynamics of propensity.

### *Nonlinear Dynamics*

The term "nonlinear dynamics" refers to patterns of change that do not proceed in a straight line. Several nonlinear dynamics will be considered, including the nonlinear dynamics of crime rates, human development, intra-individual variability, and incapacitation.

## Some Bivariate Interactive Relationships

The following outline is provided to give the reader a general sense of some of the key relationships that will be discussed. These are provided in both outline form and pictorial form. The goal is to assemble the following pieces into a solution to the criminological puzzle.

In general, an attempt has been made to develop models that involve bivariate relationships. A bivariate relationship involves two variables that combine to create an effect. For example, it is proposed that crime rates are a function of propensity and sanctioning. Behavior is a function of structure and process in the brain. A lag between the development of strength and mental capacity causes the shifts in criminal propensity over the life course.

Just as putting a puzzle together involves fitting two pieces together, it would seem that the solution to the criminological puzzle will require fitting two pieces together at a time. This analogy can only be taken so far, as the pieces do not necessarily line up linearly. However, it may be helpful to examine these pieces in advance to get some sense of what they are.

## *A Collection of Bivariate Relationships*

1. The Sigmoid Dynamics of Crime Rates
    a. Crime Rates are a Function of Two Factors
        i. A Propensity of Individuals to Harm Others In the Face of Potential Sanctions
        ii. The Propensity of Groups to Sanction Individuals Who Harm Others
    b. The Propensity for Crime is Massively Multivariate, has Complex Dynamics, and is Normally Distributed (MMCaN)
        i. Massive Numbers of Factors Create Between Individual Variation
        ii. Development and Complex Processes Create Complex Dynamics
        iii. Limiting Processes Cause Propensity to be Normally Distributed
    c. The Sanctioning Process is Both
        i. Asymmetric, and
        ii. Selective
    d. Therefore, Crime Rates Must Follow a Sigmoid Normal Response with Changes in
        i. Mean Propensity
        ii. Sanctioning Level
    e. The Quantile Function can Reveal
        i. Changes in Sanctioning
        ii. Changes in propensity
2. Between Individual Variation in the Propensity to Harm is Caused by Two Factors
    a. Nature
    b. Nurture
3. Within Individual Variation is Caused by Two Nonlinear Processes
    a. Developmental Capacity
    b. Brain Function
4. Development and the Age Crime Curve
    a. Development Follows a Nonlinear Trajectory Because of Two Processes
        i. Growth
        ii. Decline
    b. A Developmental Lag Between Two Capacities Creates an Age Propensity Curve
        i. Physical Capacity
        ii. Mental Capacity
    c. The Age Crime Curve is a Function of Two Nonlinear Factors
        i. The Age Propensity Curve
        ii. The Sigmoid Crime Curve
5. Brain Function Creates Stability and Variation Due to Two Factors
    a. Brain Structure
    b. Brain Process
6. The Age Structure of Society Affects Crime Rates Through Two Mechanisms
    a. A Propensity for Younger People to Commit More Crimes
    b. A Propensity for Older People to Provide Informal Social Control
7. Incapacitation Produces Rapidly Diminishing Returns Because of Two Processes
    a. The Sigmoid Relationship between Propensity, Sanctioning, and Crime Rates
    b. Within Individual Variation in Criminal Propensity

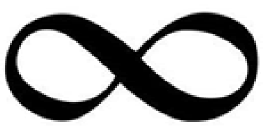
## *A Pictorial Guide to Assembling the Criminological Puzzle*

1) Crimes Occur at the Intersection between the Individual and Society

Crime is defined as "individual actions that are perceived by society to be harmful enough to warrant legal sanctions." Crime rates are a function of the propensity to harm and the societal propensity to sanction individual actions. Crime Rates = *f*[Propensity, Sanctioning]

2) The Propensity for Crime is Massively Multivariate, Complex, and Normal (MMCaN)

a) The Propensity for Crime is a Function of an Infinite Number of Factors

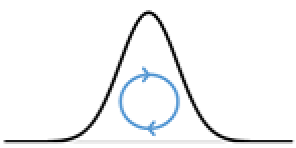


There are a limitless number of independent variables that affect the level of crime. The factors that impact crime are biological, psychological, sociological, environmental, ecological, and societal. The variables can affect both between and within individual levels of criminal behavior.

b) The Propensity for Crime has Complex Dynamics

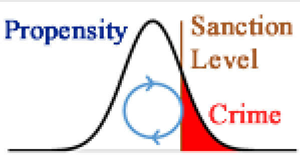

The propensity for crime has complex and chaotic dynamics. These dynamics are affected by developmental factors and brain function. There is both continuity and limitless variability in the propensity for crime.

c) The Propensity for Crime is a Dynamic and Normally Distributed



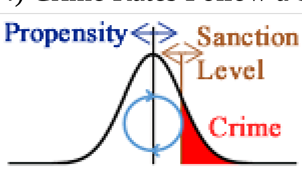
The limiting processes involved with massive between and within individual variation ensure that criminal propensity is normally distributed. The processes involved are constantly shifting and this is represented by a normal distribution with a mixing process.

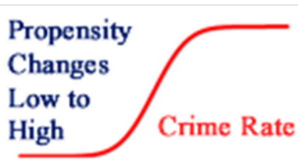
3) Societal Sanctioning is an Asymmetric Selection Process

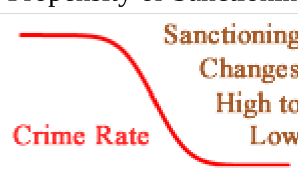



Societies sanction only a small fraction of the population for criminal behavior. This fraction tends to be comprised of individuals who are found on one side of the criminal propensity distribution. The process of sanctioning is an asymmetric selection process.

4) Crime Rates Follow a Sigmoid Response Curve With Changes in Propensity or Sanctioning

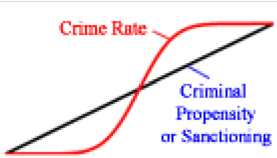



If propensity is normal and sanctioning is asymmetric, crime rates follow a sigmoid response when propensity or sanctioning changes.

5) The Quantile of the Crime Rate Returns the Propensity/Sanctioning Levels.

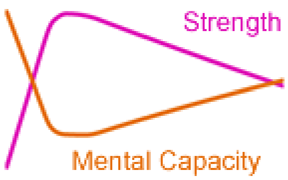



Sigmoid curves are difficult to interpret. The process of interpretation can be simplified by using the quantile funtion. The quantile of a sigmoid response curve is a stright line. It is important to the four cases causing changes in crime rates: Niether, Sanctioning, Propensity, or Both.

6) The Development of Mental Capacity Lags the Development of Strength

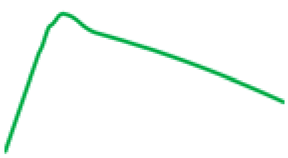

There is an approximately five year lag between the development of peak strength and peak mental capacity.  If strength provides the capacity for crime and mental capacity provides the ability to control ones behavior, then the lag between the development of strength and mental capacity could cause the age propensity curve.

7) Flip the Pieces




In order to determine how the trajectories of strength and mental capacity interact to create the age propensity curve, the trajectory for mental capacity must be flipped and subtracted from the strength trajectory.  Based upon this model, one would expect young children and older adults to have the highest frequencies of rule breaking behavior, but the least likelihood of creating serious harm to others.

8) The Age Propensity Curve is a Function of Strength and Mental Capacity

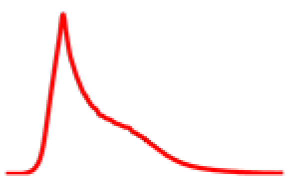


The curve on the left represents the age propensity curve.  The age propensity curve is a linear function of strength and mental capacity.

**Propensity = c + $b_1$*Strength – $b_2$*Mental capacity**

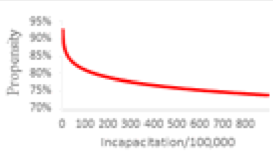
Note that the propensity for crime increases linearly and then transcribes a gradual curve before decreasing linearly over time.  This shape is more consistent with a developmental process.

9) The Age Crime Curve is a Sigmoid Normal Transform of the Age Propensity Curve



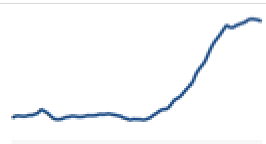
Because crime rates are sigmoid, linear changes in criminal propensity over the life course will result in sigmoid changes in crime rates over the life course.  In order to understand the nature of life-course changes in criminal propensity, the crime rates need to be transformed into the age propensity curve using inverse cumulative normal distribution functions.

10) Incapacitation Should Rapidly Lose its Effectiveness



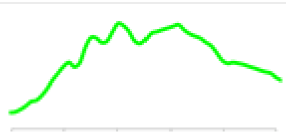

If one plots the maximum level of propensity of the people who could be expected to be incarcerated at various incarceration rates, it appears that, as the incarceration level rises, the expected utility of increased incarceration should drop rapidly.

11) Incarceration Rates Should Increase Nonlinearly with Linear Increases in Sanctioning Level



The recent increases in incarceration level in the past few decades is a good example of how asymmetric sanctioning interacts with the propensity distribution.  The increase in incarceration has experienced a nonlinear increase.

12) The Structural Effects of Age on Societal Crime Rates are a Function of Capacity and Control



Others have commented that it does not seem that the age structure of society has much impact on the crime rate.  One reason for this finding could be that criminologists are only focusing on the increases in crime due to younger populations.  It could be that large numbers of older people could also be having an effect on crime rates.  Some models will be explored.

# Chapter 2: Laying Out the Pieces

One of the first steps in putting a challenging puzzle together is to lay out the pieces. It helps to get a general view of the pieces in order to get some of ideas about their shapes and colors. One can begin the process of sorting. The straight edge pieces are pulled out from the rest of the pieces to begin the process of assembling the border. Transition pieces, which are pieces with a transition from one color to another are identified and set aside. A little time spent in preparation can save a lot of time later.

## Pieces of the Criminological Puzzle

Several authors have spent a considerable amount of time "taking stock" of what we know about crime and criminal behavior. Rather than repeat this process in depth, a brief overview of the subject of criminology will be presented. The goal is to get a general view of the pieces of the puzzle.

### *Statistical Regularities*

Much of the efforts involved in the following analyses of criminal behavior are focused at the population level. Certain statistical regularities will be examined. For example, test-retest correlations of offender risk assessment scores, self-control data, aggression indexes, etc. all seem to point to a correlation of r=.8 in the short term and r=.5 in the long term. Why is there this seeming consistency? Then, there is a prediction problem. The best predictive instruments are only able to predict about 16% of the variation in future criminal behavior? Why is there this apparent inconsistency?

The theories that follow in later chapters are intended to explain the statistical regularities in statistics related to crime and criminal behavior.

#### Males Commit Substantially More Crimes than Females

In general, males commit about for times more crimes than females. Quetelet (1833/1984) noticed this disparity when he examined crime rates in France in the early 1800s. This ratio has remained fairly consistent across time and place.

#### A Small Proportion of the Population Commits a Large Proportion of the Crimes

One of the more important considerations when studying criminal behavior is that a small portion of the population commits a large portion of the crimes. However, a large portion of the population commits a few crimes. This finding points to a distribution conundrum. What is the distribution of the propensity of individuals to harm others? Are there types of people or is there a continuous distribution?

#### Test-Retest Correlations are High in the Short Term and Moderate in the Long Term

Test-retest correlations between measures of criminological risk factors are high in the short term, averaging about r=.8. After several years, this drops to about r=.5. In general, people seem to be fairly consistent.

#### The Level of Prediction Seems to Top Out at r=.40

There seems to be an upper limit to the prediction of criminal behavior. It is rare to see any assessment instrument that predicts criminal behavior at greater than r=.40. The studies on assessment accuracy go back to studies of dishonesty by Hartheshorn and May.

### Most Crimes are Committed in Late Adolescence and Early Adulthood

Research consistently indicates that most crimes are committed in late adolescence and early adulthood. The peak ages for individual crimes vary by type.

### Diminishing Returns from Incarceration

Diminishing Returns

The literature indicates that the initial increases in incarceration had a marginal effect. However, more recent studies suggest that further increases in incarceration had little effect.

Readings

Liedka Raymond V., Piehl, Ann Morrison, & Useem, Bert (2006) The crime-control effect of incarceration: does scale matter? Criminology & Public Policy, 5(2):245–275

Owens, Emily G. (2009). More Time, Less Crime? Estimating the Incapacitative Effects of Sentence Enhancements. Journal of Law and Economics, 52:551–79.

Johnson, Rucker, & Raphael, Steven (2012). How much crime reduction does the marginal prisoner buy? Journal of Law and Economics, 55(2): 275-310.

Buonanno, Paolo, & Raphael, Steven (2013). Incarceration and Incapacitation: Evidence from the 2006 Italian Collective Pardon. American Economic Review, 103(6): 2437–2465.

## *Transition Pieces*

When solving a puzzle, it helps to look for “transition pieces.” A transition piece is a piece with two distinct colors. The transition pieces can be used to find the places where sections of the puzzle come together.

One of the greatest advances in physics occurred when scientists discovered that electrons act like a particle in some cases and a wave in other cases. The concept of a dual wave/particle nature helped make sense of a number of conflicting pieces of information. It will be suggested that the field of criminology will also be helped by looking for dual natured facets of crime and criminal behavior. These smaller mini-puzzles can be considered to be transition pieces that can help in the puzzle solving process.

**A List of Transition Pieces**

| | | |
|---|---|---|
| De Candolle’s Dilemma | Crime rates are a function of the numbers of individual actions that cause harm to others | Crime rates are a function of the level of sanctions imposed by society |
| The Age Crime Curve | Crime rates increase rapidly in childhood and adolescence | Crime rates decrease rapidly in adulthood |
| The Prediction Paradox | Evidence suggests that criminality is relatively stable. | Criminal behavior is difficult to predict with a high degree of accuracy |
| Missing Heritability | Genomes predict 50% of the variation in criminal behavior | Individual genes tend to play an insignificant role |
| The Aggression Paradox | The frequency of aggression decreases from early childhood | The frequency of crimes of aggression increases from early childhood through adolescence |

| | | |
|---|---|---|
| The Retrospection Paradox | People with extensive criminal histories share certain developmental characteristics | Children with those characteristics do not tend to grow up to become criminals |
| The Incarceration Conundrum | Increasing incarceration from small levels results in significant reductions in crime rates | Further increases in incarceration have little effect |

## De Candolle's Dilemma

Crimes are individual acts that are considered to be harmful enough by society to warrant legal sanctions. The proposition that crime rates are a function of both the propensity of a population to commit harmful acts and the likelihood that a society will institute legal sanctions has been pointed out by de Candole (1830), Durkheim (1895) and others. However, this proposition tends to be largely ignored.

The reason for ignoring the dual harm/sanction nature of crime was suggested by Quetelet (1833/1984). He suggested that there is a linear relationship between the propensity to harm others and the crime rate. If there is a steady ratio between criminal propensity and crime rates, then we can assume that crime rates are a relatively consistent indicator of the underlying level of criminal propensity.

Quetelet's linear logic has a possible flaw. If there is a nonlinear relationship between propensity, sanctioning, and crime rates, there is not a steady ratio between propensity and crime rates, and this means that both propensity and sanctioning need to be part of any model of crime rates. It will be suggested that the relationship between criminal propensity, sanctioning, and crime rates is nonlinear and the harm/sanctioning paradox cannot be ignored.

## The Age Crime Curve

Another of the findings by Quetelet (1833/1984) was that crimes increase rapidly in childhood and adolescence, come to a sharp peak in late adolescence and young adulthood, and then rapidly decline in adulthood until few crimes are committed in old age. Quetelet attributed this pattern to the developmental timing of strength, passion, and reason. It seemed obvious to him that strength and passion increase more rapidly than reason, and this lead to a sharp increase in crime in adolescence. As wisdom began to develop, and strength and passions declined, crime would also be expected to decline.

## The Prediction Paradox

One puzzle about criminal behavior is that it seems to be both stable and dynamic at the same time. Several statistics point to a fair amount of stability in criminal behavior. National recidivism statistics suggest that about 50% of people released from prison will be incarcerated again for a new crime within three years. Criminal career research suggests that the mean time to crime cessation is about 10 years for people between the ages of 20 and 40. Test/retest correlation analysis suggests that short term correlations between crime correlates is about $r=.8$. The test/retest correlation rate drops to about $r=.5$ after several years, but seems to decrease slowly.

Given the seemingly stable nature of factors related to crime, it would seem that criminal behavior should be relatively easy to predict, but this is not the case. Single measures such as past criminal history can predict crime at about $r=.2$, which explains about 4% of the variance, but the predictive accuracy appears to top out at about $r=.4$, which only explains about 16% of the variance. This suggests that criminal propensity is highly dynamic. How can something be stable and dynamic at the same time?

## Missing Heritability

Twin studies suggest that about 50% of the variance in criminal behavior can be explained by a person's genetic makeup. These studies use a person's entire genome to predict criminal behavior. However, there is a missing heritability problem. Studies that try to use individual genes to predict criminal behavior can only explain small amounts of variance. Where is this "missing" heritability?

## The Aggression Paradox

Tremblay and others have studied aggression over the life-course. They find that the frequency of aggressive acts is declining as children get older. However, the crime rate trends indicate that the frequency of crimes of aggression is increasing through adolescence. How can the frequency of aggressive acts be declining while the frequency of crimes of aggression is increasing?

## The Retrospection Paradox

When surveying persistent criminals, there appear to be several developmental histories that are shared in common. However, if one tries to begin with a set of children, and follow them for an extended period, many children have backgrounds similar to those of persistent criminals but do not grow up to become criminals. Why don't children, who seem to have childhood characteristics similar to those of persistent criminals, grow up to become persistent criminals?

## The Incarceration Conundrum

When countries began the incarceration buildup in the 1970s, there appeared to be some initial reductions in the crime rate. However, as time went on into the 1990s, and the incarceration rate continued to climb, further reductions in the crime rate did not seem to occur. Why would small increases in incarceration rates have an effect, but larger increases have little or no effect?

## A Set of Transition Pieces

Using the puzzle analogy, these conundrums and paradoxes can be considered to be transition pieces. Transition pieces are puzzle pieces where the pattern of colors changes within the piece. These pieces show where the transitions from one section of the puzzle to another are occurring. These puzzling findings can be used to help make sense of the large volume of information related to criminal behavior.

# Chapter 3: Thinking Differently

An examination of the criminological literature suggests that 80% of the models presented in this book were discussed in some form by previous authors. These earlier discussions did not become part of the mainstream criminological literature. Why?

The importance of this questions seems to go beyond mere intellectual curiosity. If historic trends are any indication, the ideas presented in this book will probably be difficult to accept. At least some attempt needs to be made to suggest that it is worthwhile to think differently about these matters.

There seem to be a number of reasons that these ideas have been passed over. If there were one word to describe the problem, it would seem to be "simplicity." Theorists are looking for simplicity.

A theory that proposes a single cause is simpler than a theory that proposes an infinite variety of causes. A theory that proposes a taxonomy is simpler to work with than a theory that proposes a continuous range of criminality. A method that separates the important from the unimportant seems to make the scientific process simpler than assuming that almost everything has some level of importance. Linear models are easier to work with than nonlinear models. The list goes on.

The efforts to find simple relationships are admirable, and even necessary. However, at some point, there is a need to recognize that the world probably isn't as simple as we would like it to be. When simple models start to impede progress, there is a need to go beyond the simple and start trying to build models that provide a more realistic picture of what is actually going on.

The basic premise in the arguments that are presented in this book is that the real world is not as simple as many of the current scientific models would suggest. Events in the real world are complex and subject to almost infinite variation. Small things add up until they become big things. Much of the world is curved and does not fit a straight line model. As scientists, we need to deal with this complex nonlinear world.

The solutions that are proposed in this book represent a somewhat different way of thinking. There are a number of ways that the proposed solutions to the criminological puzzle vary from the current scientific model. Before going on to the proposed solution, some effort will be taken to discuss the conceptual issues involved.

The goal is to develop models that are "as simple as possible."

## Lombroso's Dilemma

The essential problem faced by criminologists is expressed by Lombroso's Dilemma. Lombroso began with the assumption that crimes were caused by hereditary factors. After years of analysis, Lombroso realized the heredity was only one of many cases of crime. Lombroso recognized that crimes were complex phenomena, but he also recognized the need to study causes, one at a time. Lombroso (1899/1911; p. 1) noted that "EVERY crime has its origin in a multiplicity of causes, often intertwined and confused, each of which we must, in obedience to the necessities of thought and speech, investigate singly." This statement will be referred to as "Lombroso's Dilemma."

As criminologists, we must pay heed to "Lombroso's Dilemma." We need to recognize that we, as theorists, have a psychological need to study individual causes "in obedience to the necessities of thought and speech." However, we must not forget that there are an almost limitless number of causes of criminal behavior that are "often intertwined and confused." In addition to ceteris paribus theories, we need some way to develop theories that provide models involving aggregate causes.

# Three (Over)Simplifying Assumptions

There are three oversimplifying assumptions that bear mentioning. There are the career criminal taxonomy, the criminal career paradigm, and the ceteris paribus theoretical approach. The problems with these approaches will be discussed below.

## *Risk Factors Can Be Turned into General Theories*

A popular practice in criminology is to examine one risk factor at a time. This practice is fine, as long as it is recognized that the risk factor is one of many risk factors. This practice is problematic when attempts are made to turn risk factors into a general theory of crime. (i.e. Gottfredson & Hirshi, 1990).

The more popular theories in criminology are "ceteris paribus" theories. A ceteris paribus theory can be stated as "all other things being equal, X causes Y." Replace X with your favorite cause and Y with your favorite effect. These theories are based upon probabilistic causation. That is,

$$P(Y \text{ With } X) > P(Y \text{ Without } X).$$

The most common process of testing ceteris paribus theories is called "null hypothesis significance testing (NHST)." The basic premise of NHST is that if X causes Y, then there should be a statistically significant relationship between X and Y. If the statistical significance is less than .05, we then claim that there is no evidence that X causes Y. In plain terms, if the significance cannot be established, X is considered to be an "insignificant" factor.

While there is some merit in identifying the significant risk factors, there are some major problems with this approach. If we take the missing heritability conundrum as an example, it appears that the aggregate effect of genetic predisposition explains about 50% of the variation in criminal behavior, but individual genes only explain about 5% of the variation. This implies that 45% of the variation is explained by either insignificant factors, or some type of complex interaction between multiple significant factors. It would seem that the search for significance is not going to be productive. (Read Plomin's work on Polygenic traits).

There needs to be some way to create models that account for the large amounts of variation that is the result of many endless and possibly insignificant causes coming together in a particular instant in time. We need to figure out how to move beyond ceteris paribus theories to build aggregate theories of crime. This will be a challenging proposition.

## *Career Criminal Taxonomies*

The career criminal taxonomy divides people into two or more types. The simplest taxonomy is a two type model. In the two type model, there are career criminals and ordinary citizens. This model needs to be falsified. If criminal propensity is continuous, then a taxonomy is not appropriate.

## *Criminal Career Trajectories*

The criminal career model is based upon the assumption that people start from a non-offending pattern, acquire some form of criminal lifestyle, and then desist from crime. The trajectory of the criminal career is modeled as a box over the life course. This model also need to be falsified. An examination of individual risk trajectories reveals that criminal propensity is fluctuating. There is no box trajectory.

# The Failure of More Complex Models

More complex models have not done well in criminology. Two types of models will be examined. The first is multiple factor theory and the second is the assumption of normality.

## *Multiple Factor Models*

To illustrate the conceptual problems with aggregate theories more clearly, it will be helpful to examine the failure of the multiple factor theory. The multiple factor theory began in the early 1900s and has almost completely fizzled out. The reasons for this seem to be tied to our ideas of what is and is not a theory.

Lombroso (1876) had begun with the proposition that crime had a single cause, and that was heredity. However, after looking closely at several hundred case studies, Lombroso (1899/1911) concluded that crime had many causes, with heredity being only one of those causes. Following Lombroso, Healy (1910) conducted his own assessment of delinquents and came to a similar conclusion. He noticed that delinquency had many causes and suggested that trying to limit the study of crime to single causes was "unscientific."

Further work on the multiple factor theory was done by Burt (1925) and Elliott and Merrill (1934; 1941). There seemed to be a consensus that persistent criminal behavior was caused by the additive effects of many factors in combination. The concept of additive effects seems to have been captured by Burt (1925; p. 575), who noted "Crime is assignable to no single universal source, nor yet to two or three: it springs from a wide variety, and usually from a. multiplicity, of alternative, and converging influences. So violent a reaction as may easily be conceived, is almost everywhere the outcome of a concurrence of subversive factors: it needs many coats of pitch to paint a thing thoroughly black."

Elliott and Merrill (1941; p. 111) put it clearly, "On the other hand, the delinquent child is generally a child handicapped not by one or two, but usually by seven or eight counts. We are safe in concluding that almost any child can overcome one or two handicaps, such as the death of one parent or poverty and poor health. But if the child has a drunken unemployed father and an immoral mother, is mentally deficient, is taken out of school at an early age and put to work in a factory, and lives in a crowded home in a bad neighborhood, nearly every factor in his environment may seem to militate against him. Such children constitute the largest share of those who get into serious trouble and are brought into court."

These statements by the multiple factor theorists seem to provide a very clear and concise theory of criminal behavior. Their theory states that crime is caused by the aggregate effects of many factors. However, the multiple factor theory has been subject to considerable criticism.

One of the first to criticize the multiple factor theory was Sutherland (1934; p. 48), and his thoughts seem to reflect the prevailing view by criminologists. He noted that, "A multiple factor theory is undoubtedly closer to the facts than the earlier theories, but since the quantitative and qualitative relations between the several factors are not known it is unsatisfactory for purposes of understanding, of control, and of prevention." His position seemed to be that the multiple factor theory may be accurate, but it has little utility.

Other theorists took a more aggressive stance and questioned whether the multiple factor theory is even a theory. For example, Cohen (1970; p. 78) suggested that the multiple factor theory is the "abdignation of theory." The term abdignation would seem to be equivalent to rejection. Cohen seems to be suggesting that the multiple factor theory is "rejecting" the theoretical approach. Does this mean that if a theory does not propose some specific cause, it is not a theory?

As a point of interest, it should be noted that, although it is not treated in the literature as an outgrowth of multiple factor theory, the multiple factor approach is used on a regular basis in the process of offender risk assessment. Offender risk assessment tools are constructed by adding the values of many variables together from several theoretical orientations in order to improve predictive accuracy (cf. Hart, 1923; Burgess, 1928). However, even in the risk assessment community, the process of aggregating variables from many theoretical orientations is criticized as "dustbowl empiricism" (Bonta, 1997). Again, the inductive nature of these observations is seen as unscientific.

Somehow, if an aggregate approach is to be successful, there would seem to be a need to consider whether an aggregate approach is a theory or not. Perhaps a brief overview of theories is in order.

## The Purpose of Theory

Dubin (1969) proposed that theory building has two goals, prediction and understanding. Reynolds (1971) expanded upon this idea suggesting that theories have five goals.

(1) A method of organizing and categorizing "things," a typology;
(2) Predictions of future events;
(3) Explanations of past events;
(4) A sense of understanding about what causes events.
(5) The potential for control of events.

An examination of the multiple factor theory suggests that it fails the first test and passes the other four. The multiple factor theory does not provide a typology, and it could even be seen to be the rejection of a typology. However, the multiple factor theory provides better prediction because the combination of a variety of different types of measures provides more accurate prediction than single measures. Similarly, multiple explanations of past events are typically more accurate than single explanations. A sense of greater understanding is possible when one considers that crime is the result of the effects of cumulative risk factors. Finally, the multiple factor approach provides greater control of events. Note that research indicates that the most effective interventions intended to reduce criminal behavior involve treating multiple risk categories.

The results of this brief analysis suggest that unless providing a typology is an essential part of theory building, a multiple factor theory is a theory. It will be suggested that a typology is not an appropriate basis for criminological theories and that a multiple factor approach is preferred.

## Moving beyond Lombroso's Dilemma and Ceteris Paribus Theories

The purpose of this book is to provide a set of conceptual and methodological innovations for moving beyond the ceteris paribus approach, and working on the other side of Lombroso's Dilemma. In order to do this, an entirely different set of skills are needed.

Setting aside the debate about whether the multiple factor theory as a theory or not, it seems clear that there are an almost limitless number of factors associated with criminal behavior. Consider that the FBI lists over 50 different types of crime. It seems logical that each of these various behaviors is due, at least in part, to different causes. Robinson (2002) suggested that criminal behavior is related to factors at the cellular, organ, individual, group, community, and societal levels of analysis. His analysis left out environmental and situational factors. Ellis, Beaver, and Wright (2009) catalogued hundreds of factors in many different areas of study that are related to crime. Agnew and Cullen (2010) list fifty different theoretical articles as "essential reading" and suggest that many theoretical orientations were left out to get the number down to fifty. Finally, the missing heritability problem suggests that crime is "polygenic" and many individual genes are related to criminal behavior. It seems clear that crime is a function of limitless numbers of variables.

The process of working with aggregate theories and infinite causes is different from the process of working with individual causes. These differences are spelled out below. Aggregate theories work from the top down rather than the bottom up. Models are built with the premise that there is limitless variation. Some of the differences in approach are listed below. The analogy of solving a puzzle is used to help clarify some of these ideas.

**Proposed Alternative Methods of Analysis**

| **Description** | **Standard Science** | **Proposed Alternatives** |
|---|---|---|
| Perspective | Bottom Up | Start from the Top Down |
| Puzzle Solving | Looking at Pieces | Look at the Big Picture |
| Effort | Cutting Edge | Study the Classics |
| Replication | Do it Over | Move On to the Next Piece |
| Focus | Mean Centered | Work on the Edge |
| Size | Samples | Work with the Average Man |
| Modeling | Limited Causes | Assume Limitless Causes |
| Certainty | Deterministic | Build Probabilistic Models |
| Insignificance | Null | Study Small Effects |
| Analysis | Discrete | Build Continuous Models |
| Scope | Individual Causes | Try to Aggregate Causes |
| Theory | Deductive | Use Inductive Methods |
| Causality | Causal | Study Emergence |
| State | Static | Assume Propensity is Dynamic |
| Dynamics | Linear | Study Nonlinear Dynamics |
| Data | Real | Build Models with Imaginary Data |
| Models | Simple | Build Complex Models |
| Psychometrics | True Score | Study Intra-Individual Variation |
| Measurement | Dichotomous | Use Ratio Variables |

## *Perspective: Top Down vs. Bottom Up*

There are two primary ways to try to solve puzzles. One can begin at the bottom and try to fit the individual pieces together until the bigger picture emerges, or one can begin at the top from a general outline and try to work down. While both approaches need to be used at some point, beginning with the top down approach can often produce faster solutions. To provide a relevant example, take a look at the age crime conundrum. In a recent article, Piquero, Sweeten, and Steinberg (2013) built a statistical model of the age crime curve using many of the available variables. Using this “bottom up” approach, they were able to explain about 60% of the variance. In a “top down” model proposed later in this book, the top down model explains 99.99% of the variance. While the bottom up approach is helpful, it would seem that the top down approach might be more productive.

## *Puzzle Solving: Looking at the Big Picture vs. Looking at the Pieces*

One of the more prevalent puzzle solving techniques of standard science is to look at the pieces. For example, hundreds of studies have been done to determine whether low self-control is related to criminal behavior. This is like looking at a single piece of the criminological puzzle. The alternative is to look at the big picture. Crimes are individual acts that are considered by society to be harmful enough to warrant legal sanctions. If we look at piece of the puzzle provided by self-control, it seems logical to assume that people who fail to consider the consequences of their actions might have a higher arrest rate. Especially since one of the "consequences" is the possibility of legal sanctions. However, if we look at the big picture, it seems short sighted to claim that low self-control "explains all crimes at all times." While control theories are certainly an important piece of the criminological puzzle, there are hundreds of other factors involved in determining why some people harm others and some actions are sanctioned.

## *Theory: Inductive vs. Deductive*

The scientific process seems to have become wedded to the idea that theories must be deductive rather than inductive. The deductive process begins with a theoretical proposition and tests it. For example, a theory that A causes B would be tested by showing that B occurs whenever A is present. An inductive process starts with an observation of the facts and builds a model based upon what is found. The inductive process is often seen as atheoretical, but it need not be. For example, the multiple factor theory of criminal behavior states that crimes have many causes and that persistent criminality is the result of many factors interacting. This is an inductive theory based upon observation that is probably more valid that any deductive theory. Induction is a core skill set that needs to be given a more prominent place in the scientific process.

## *Focus: Edge Centered vs. Mean Centered*

It seems safe to say that most scientific efforts are focused on trying to find the mean value of something. This tradition is exemplified by Quetelet's (1833/1984) concept of the "average man." While "mean centered" science has its place, crime is not mean centered. Crime is "edge centered." In general, people who persistently commit serious crimes are not average. The average person is not consistently committing serious crimes. The propensity for crime is out on one edge of the propensity distribution, several standard deviations from the mean. In the models that follow, the focus is on building "edge centered" models of crime rather than "mean" centered models.

## *Certainty: Probabilistic vs. Deterministic*

Scientists tend to try to model deterministic theories. For example, a deterministic theory could be "strain causes crime." While the strain theory is usually not phrased in this way, this is the basic working premise. We then try to "falsify" this theory by "proving" it is false. If we can't prove it is false, the conventional logic is that it must be true. A probabilistic model would suggest that strain is one factor out of the many thousands of causes of crime. Where strain is present, crime is more probable. However, strain does not, in and of itself, "cause" crime.

## *Causality: Emergent vs. Causal*

The causal model is based upon the idea that there is a cause and an effect. This assumption may not be warranted. As we study the world, we are finding that most behavior is complex. Human behavior "emerges" from the billions of interactions between many millions of brain cells. We somehow need to make sense of this emergent process and how it affects the way that we think of causality.

## *Scope: Aggregated Causes vs. Individual Causes*

Criminologists tend to prefer theories that focus on individual (i.e. single) causes. Most criminological theories focus on individual causes, although a handful of theories are "integrated" to cover a few causes. The multiple factor approach is an "aggregated" theoretical approach. With theory aggregation, little effort is spent trying to determine individual causes. The aggregate approach is thought to be "atheoretical" because it does not focus on the individual causes of crime. However, it is suggested that the proposition that "*crime has many causes that are additive*" is a valid theoretical position. There is probably much more evidence suggesting that crimes have many causes than there is evidence that crimes have a single cause. The proposition that crimes result from multiple causes from multiple theoretical orientations is a valid theoretical position.

## *Modeling: Limitless vs. Limited*

It is a common practice to build statistical models with several variables and an error term. The "error" is partly measurement error, but much of what is referred to as error is due to the effects of the limitless factors that were left out of the model. Usually, the amount of error is larger than the amount of explained variance. It is suggested that rather than presume that the dependent variable is "caused" by the limited number of factors included in the model, with some error, the basic presumption should be that the dependent variable has limitless causes, some of which are included in the model. This proposition might not seem to be useful at first, but this idea will turn out to provide the basis for a new way of working with the criminological puzzle.

## *Insignificance: Small vs. Null*

The basic scientific model used by many criminologists is based upon the presumption that insignificant factors are "null," which means that they have no effect and can be ignored. This model is not based on "reality." In the "real" world, the combined effects of insignificant factors explain more of the variance than the significant ones. An insignificant factor has a "small" effect rather than "no" effect. For example, the missing heritability conundrum occurs because a "genome" is a highly significant factor related to the causes of crime, but most individual "genes" provide small and insignificant contributions. It is suggested that criminologists need to move away from a null model of insignificance begin studying the aggregate effects of many insignificant factors.

## *Dynamics: Nonlinear vs. Linear*

The study of "dynamics" is the study of patterns. Much of the effort in scientific endeavors is focused on finding linear patterns. Linear math is relatively easy to work with. The formula ($X = a + bY + e$) is fairly easy to model. However, the "real" world is rarely linear. The real world often has "nonlinear" dynamics. A set of nonlinear models will be proposed. These models begin with the presumption that the world is nonlinear and that there are several nonlinear processes occurring at once. It is suggested that this nonlinearity must be accounted for in modeling crime rates.

## *Models: Complex vs. Simple*

Scientists like simple models. However, the world appears to be complex rather than simple. In the model of the age crime curve that will be presented, it is suggested that three nonlinear dynamics need to be considered. Two of the dynamic models are deterministic and the third is chaotic. Putting these models together is not a simple process. However, it could be argued that the complex model is actually simpler than trying to collect data on sixty different variables. It is suggested that criminologists may need to start looking at more complex models.

### *State: Dynamic vs. Static*

Much of the work in criminology is based upon the premise that there are static relationships between variables. The models that are presented in this article are based upon the premise that relationships are dynamic and changing over time. This requires an analysis of the "dynamics" or patterns of change. The study of dynamics involves looking at how things change over time with changes in other variables. For example, the dynamics of crime rates are sigmoid. As propensity or sanctioning change over time, crime rates will follow a sigmoid response curve. Development has another nonlinear dynamic pattern, and individual propensity follows a third nonlinear dynamic pattern. The study of dynamics represents a fundamentally different way of looking at the criminological puzzle.

### *Psychometrics: Intra-Individual Variation vs. True Score*

It seems safe to say that much of the work in the field of psychometrics is based on a true score model, and it is suggested that the true score model ignores the importance of intra-individual variability. The true score model begins with the presumption that the average value of repeated measurements represents the person's "true score." In the true score model, it is presumed that a measurement (X) is the sum of a true score (T) and an error term (e) as represented in the formula [$X = T + e$]. It is proposed that over repeated measurements the sum of the errors equals zero [$\sum e = 0$]. Therefore, the true score (T) is equal to the average measurement (X) obtained over many repeated measurements [$T = (\sum X)/N$]. An alternative proposition is that repeated measurements represent intra-individual variation in the property being measured. The "error" (e) in the true score model is actually the result of errors in measurement ($e_M$) and actual "change" (C) in the characteristic being measured [$e = e_M + C$]. While the errors in measurement ($e_M$) may sum to zero, one cannot assume that the traditional errors (e) will add up to zero because real change may also occur. For example, if I go on a diet and my weight goes from 200 to 190 and back to 200, is my "true" weight 195 pounds, or did some intra-individual variation occur and my weight actually changed from 200 to 190 and then back to 200? This is an important question when examining the dynamics of criminal propensity. True score models cannot be used to model a dynamic process. A model based upon the presumption of intra-individual variability is needed.

### *Analysis: Continuous vs. Discrete*

In looking at the types of analysis used in criminology, the question arises, is criminality a discrete categorical variable or a continuous variable? Criminal career models are based upon the idea that people can be placed into discrete categories. For example, Moffitt's life course taxonomy is based upon the presumption that there are three types of people, non-offenders, adolescent limited offenders, and life-course persistent offenders. In a continuous model, there are no categories. In is presumed that there is continuous variation from one person to the next. It will be suggested that the continuous model is preferable to a discrete taxonomy because it provides a better model of the "real" world.

### *Measurement: Ratio vs. Dichotomous*

Criminologists have tended to use crime as the dependent variable, but it is difficult to study crime using anything more complicated than a dichotomous variable. Crimes tend to be low base rate phenomena. Therefore, if someone commits a crime, it is notable. However, dichotomous variables do not tell us much about what is really happening. The proposed solution to this problem is to shift the focus to using criminal propensity as the dependent variable. Criminal propensity can be measured as a continuous variable.  There are many fairly accurate measurement instruments that can be used to assess criminal propensity and these permit the analyses to focus on a ratio level variable, rather than a dichotomous variable.  It is suggested that switching from a study of crime as the dependent variable to the study of criminal propensity as the dependent variable will provide much more information about why people commit crimes.

## Challenging Assumptions

It is hoped that these discussions have produced some questions in the reader's mind.  Are our current assumptions getting us where we need to be?  Or, should we look at some new assumptions and start building some new scientific methods?

# Section 2: Theory

# Chapter 5: Crimes are Harms that are Sanctioned

The first step in developing a statistical model of crime is to determine which variables must be in in the model. It seems that we must consider the fact that crimes occur at the intersection between the individual and society. Crimes are individual acts that are considered by society o be harmful enough to warrant legal sanction.

## The Mathematical Function Defining Crime Rates

De Candolle (1830) appears to be one of the first to mention the importance of considering the mathematical relationship between the propensity of a population for harming others, the sanctioning process, and the resulting influences on crime rates. This discussion apparently resulted from some events that occurred after crime rates in France started being published in 1827. It seems that newspapers were printing commentaries that were equating crime rates with the propensity for committing crime. De Candolle (1830) argued that one could not equate crime rates with the propensity for crime because there was a possibility sanctioning was a variable. He noted that regional differences in crime rates might be caused by regional differences in sanctioning levels. Decandolle proposed that crime rates are a function of propensity and sanctioning.

$$\text{Crime Rates} = f(\text{Propensity, Sanctioning}) \qquad \text{Equation 1}$$

Quetelet (1833/1984) argued that the sanctioning process might not be capturing all of the crime, but he discounted the possible effects of variation in sanctioning. He argued that the relationship between crime rates and criminal propensity was some type of ratio. Some crimes might not be sanctioned, but the effects of variation in sanctioning were not important because there was probably a linear relationship between crime rates and the propensity for crime.

Another early work that seems to relate directly to the mathematical relationship between propensity, sanction, and crime rates appears to be the discussions by Durkheim (1895). He noted that both crime and sanctioning are both normal. I think his statements make more sense if we assume that his use of the word “crime” is really related to the concept of “propensity to harm.” If we take this position, Durkheim (1895) was suggesting the propensity to harm is normal and sanctioning harms is also normal.

The essence of Durkheim’s (1895) discussion is on variations. He is arguing that there is normal variation in both the propensity of individuals to harm others and the likelihood of a society to sanction harmful behaviors. This position seems to point to something very important. What is the mathematical relationship between crime and sanctioning?

One of the more important attempts to define the mathematical relationship between propensity and sanctioning is found in the criminal career model. This is clearly a linear model, although there are attempts to build some nonlinearity into the model by assuming groups of people with similar offending patterns. The criminal career model was developed independently by Avi-Itzhak and Shinnar (1973) and later expanded by Shinnar and Shinnar (1975) and another version was developed by Greenberg (1975). An extensive study of criminal careers was conducted by Blumstein et al.

I will be arguing that linear models are, in a word, wrong. The relationship between propensity, sanctioning, and crime is not linear. The relationship is nonlinear. If there is a nonlinear relationship between propensity, sanctioning, and crime rates, one cannot ignore the effects of both variation in propensity and variation in sanctioning. One must account for the fact that crime rates are a function of variation in two main variables, propensity and sanctioning.

## Crime as Harm

It will become important later in the development of theory to establish that crimes are individual actions that are considered harmful.  There may be some argument about this proposition because some crimes just do not seem that harmful.  However, there is either real or perceived harm in every crime.  Someone, somewhere decided that a particular act was harmful enough to warrant legal sanctions.

### *The Propensity for Crime*

In the formulas that follow, the concept of a propensity for crime will be used.  Given that crime is a function of individual actions that are perceived harmful enough to warrant sanctions, the propensity for crime should reflect both a propensity to harm and a propensity to ignore legal sanctions.

The discussions regarding this topic are typically causal in nature.  People want to know why one person may have a higher propensity than another.  The purpose of this book is to discuss the nature of the mathematical properties of the propensity for crime.  The fact that there are multiple factors influencing the propensity for crime is more important for this process than determining what those factors are.

and sanctioning in the model of crime.  This is the first step in solving the criminological puzzle.

## The Sanctioning Process

The next step will be to explore the sanctioning process.  Sanctioning has several steps.  There is a selection process whereby societies decide which action to sanction.  Police decide which laws to enforce with each individual and each situation.  Prosecutors decide whether to pursue legal sanctions in each situation.  Finally, judges and juries decide whether to impose sanctions.  This is a selective process.

### *The Justification for Sanctions*

#### The Early Years: Justice

The initial discussions regarding harm and sanctioning probably go back to prehistory and talks around the campfire about what to do about the person that stole something.  We can't document these early discussions.  However, the earliest remaining written works include records of legal sanctions.  The laws in those days were literally "set in stone."  These laws seemed to be focused on ideas of fairness and justice.

One of the oldest surviving legal codes was developed by Ur-Nammu at about 2100 BCE.  This code spelled out numerous sanctions.  A sample adapted from Roth (1997: pp. 17-19) is provided below.

> 1 If a man commits a homicide, they shall kill that man.
>
> 3 If a man detains another, that man shall be imprisoned and he shall weigh and deliver 15 shekels of silver.
>
> 8 If a man acts in violation of the rights of another and deflowers the virgin slave woman of a man, he shall weigh and deliver 5 shekels of silver.
>
> 18 If [a man] cuts off the foot of another man, he shall weigh and deliver 10 shekels of silver.

These early laws followed the principle of "an eye for an eye" (Williams, 2006). There was a belief that the punishment should fit the crime. These codes became the basis for many of our modern ideas about justice and fairness in the legal system.

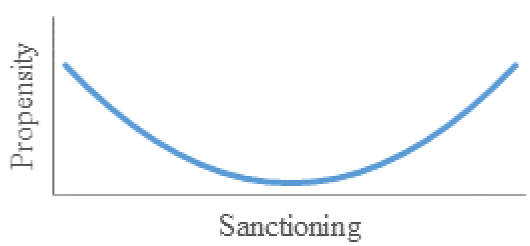
### Beyond Justice: Deterrence

In the middle ages, some punishments appeared to be going above and beyond what might seem to be simple retribution for an act. Several theorists commented on this and argued for a more balanced approach. They recognized that individuals harm others and that societies should design sanctions that were only harsh enough to deter others from committing these harmful acts (cf. Beccaria, 1769; Bentham, 1784). These discussions ushered in the idea that deterrence should be the goal of sanctioning.

The mathematical form of the proposed relationship between sanctioning and the propensity to harm others was nonlinear. Up to a certain point, it was thought that sanctions should cause a reduction in the propensity for crime, but if punishments became too severe, it was proposed that this would cause an increase in crime. For example, Beccaria (1769/1882; p. 94) wrote,

> If punishments be very severe, men are naturally led to the perpetration of other crimes, to avoid the punishment due to the first. The countries and times most notorious for severity of punishments, were always those in which the most bloody and inhuman actions and the most atrocious crimes were committed; for the hand of the legislator and the assassin were directed by the same spirit of ferocity: which on the throne, dictated laws of iron to slaves and savages, and in private instigated the subject to sacrifice one tyrant, to make room for another.

A plot of the theoretical relationship between the level of sanctioning and the propensity for crime would look like the "U" shaped plot shown below. As sanctioning increases, the propensity of individuals to harm others decreases until it reaches an optimal level. At that point, further increases in the severity of the sanctions are thought to cause an increase in the propensity for crime.




### Beyond Deterrence: Rehabilitation

The next iteration of the propensity/sanctioning discussion was based upon the idea that sanctioning should be used to rehabilitate the offender. This concept was inherent in the concept of a "penitentiary," which was supposed to provide a place for the offender to meditate upon the errors of their actions.

Benjamin Rush (1787) appears to be one of the first to espouse the move from punishment to rehabilitation. From an examination of his writing, it seems clear that he argued that public punishment would create a greater propensity for crime and not less propensity.

> I. TH E reformation o f a criminal can never be effected by a public punishment for the following reasons:

> 1. AS it is always connected with infamy, it destroys in him the sense of shame, which is one of the strongest outposts of virtue.
>
> 2. IT is generally of such short duration as to produce none of those changes in body or mind which are absolutely necessary to reform obstinate habits of vice.
>
> 3. EXPERIENCE proves that public punishments have increased propensities to crimes. A man who has lost his character at a whipping-post has nothing valuable left to lose in society. Pain has begotten insensibility to the w hip, and shame to infamy. Added to his old habits of vice, he probably feels a spirit of revenge against the whole community whose laws have inflicted his punishment upon him; and hence he is stimulated to add to the number and enormity of his outrages upon society. The long duration of the punishment, when public, by increasing its infamy, serves only to increase the evils that have been mentioned. The criminals who were sentenced to work in the presence of the city of London upon the Thames during the late war, were prepared by it for the perpetration of every crime, as soon as they were set at liberty from their confinement. I proceed,
>
> II. TO shew, that public punishments, so far from preventing crimes by the terror they excite in the minds of spectators, are directly calculated to produce them.

Rush (1787) suggested that the punishments should be designed to fit the crime. If the proper punishment were found, the person would be less likely to commit crimes in the future.

> IN order to render these punishments effectual, they should be accommodated to the constitutions and tempers of the criminals and to the peculiar nature of their crimes. Particular attention should be paid, likewise, [to] the nature, degrees, and durations of punishments [for] crimes [arising] from passion, habit or temptation.
>
> THE punishments should consist of BODILY PAIN, LABOU R, WATCHFULNESS, SOLITU DE, and SILENC E. They should all be joined with CLEANLINESS and a SIMPLE DIET. To ascertain the nature, degrees, and duration of the bodily pain will require some knowledge of the principles of sensation and of the sympathies which occur in the nervous system. The labour should be so regulated and directed as to be profit able to the state. Besides emptying criminals in laborious and useful manufactures, they may be compelled to derive all their subsistence from a farm and a garden cultivated by their own hands [and] adjoining the place of their confinement.
>
> THESE punishment s may be used separately or [may be] more or less combined, according to the nature of the crime, or according to the variations of the constitution and temper of the criminal. In the application of them, the utmost possible advantages should be taken of the laws of the association of ideas, of habit, and of imitation.
>
> TO render these physical remedies more effectual, they should be accompanied by regular instruction in the principles and obligations of religion by person s appointed for that purpose.
>
> THUS far I am supported in the application of the remedies I have mentioned for the cure of crimes by the facts that are contained in Mr. Howard’s history of prison s, and by other observation s. It remains yet to prescribe the specific punishment that is proper for each specific crime. Here my subject begins to oppress me. I have no more doubt of every crime having its cure in moral and physical influence than I have of the efficacy of the Peruvian bark in curing the intermitting fever. The only difficulty is, to find out the proper remedy or remedies for particular vices.

Older rehabilitation models appear to suggest a linear reduction in propensity for increases in rehabilitative sanctioning. More recent models of rehabilitation suggest that too much sanctioning could be detrimental, and so the same “U” shaped curve as is shown above should apply to rehabilitative sanctions.

## Beyond Rehabilitation: Incapacitation

In the early 1970s, rising crime rates crated a general disillusionment with the possibility of either deterring crime or rehabilitating offenders. The next step in the sanctioning progression was incapacitation. Theoretically, if offenders are locked up, they are “incapacitated” from committing crimes. When the discussions of incapacitation began, the discussions turned from trying to reduce the propensity of individuals to harm others to trying to reduce the harm creating capacity of the population as a whole. In theory, in a society where all harm doers are locked up, there should be no crime.

# Section 2A: Criminal Propensity is Massively Multivariate, Complex, and Normal (MMCaN)

The purpose of chapter four was to demonstrate that crime is a bivariate process. Crime rates are a function of both the propensity of individuals to harm others, and the propensity of society to institute sanctions. The key to understanding this function is to look at the nature of criminal propensity, sanctioning and crime rates.

The first step in developing a bivariate model of crime rates is to look at the nature of criminal propensity. It will be proposed that the propensity for crime is massively multivariate, complex, and normal (MMCaN). One might wonder why this terminology is being used instead of just saying "criminal propensity is normal." I am using this term because it provides a more accurate description of reality. A normal distribution seems to be static. When we look inside however, we find something very dynamic. We need to recognize that the normal shell is hiding the dynamic processes inside.

By using the term MMCaN, I will be suggesting that the propensity to harm is a function of massive numbers of variables that fall into several categories which include heredity, environment, development, capacity, and situation. The model presumes that there is considerable fluctuation in individual propensity levels that is a function of development and complex processes. Finally, given the massively multivariate nature of the propensity for crime, the central limit theorem tells us that the propensity for crime must be normally distributed. Since a normal distribution might suggest something static, and many of the variables affecting individual propensity levels are complex and highly dynamic, a mixing process is indicated. The MMCaN distribution can be visualized below as a normal distribution with a complex dynamic mixing process.

Criminal Propensity is Massively Multivariate, Complex, and Normal (MMCaN)

There are a limitless number of independent variables that affect the level of crime. The factors that impact crime are biological, psychological, sociological, environmental, ecological, and societal. The variables can affect both between and within individual levels of criminal behavior.

Human behavior has complex and chaotic dynamics. These dynamics are affected by developmental factors and brain function. There is both a measure of continuity and limitless individual variability in the propensity for crime.

Because there are a limitless number of independent variables that affect the propensity for crime, the limiting process guarantees that the shape of the propensity distribution is normal. Because processes involved are highly dynamic, there is a mixing process in the normal distribution.

# Chapter 6: Criminal Propensity is Massively Multivariate

The first theoretical premise is that criminal propensity is a function of an infinite variety of causes. The working hypothesis is that any list of the causes of crime is incomplete. No matter how many causes of crime are discovered, more causes can be found.

The proposition that crimes have many causes is not a new idea. There was an effort to try to build a multiple factor theory based upon this premise in the early 1900s. However, the concept that crime has many causes has tended to be resisted. The basis of the resistance to multiple factor theory seems to be based upon Lombroso's paradox. Restated, Lombroso's paradox tells us that, crimes have many causes, but because our cognitive capacity is limited, we must look at each cause separately. This need for a single focus seems to have led to the idea that a theory that crime has many causes is not a theory.

## *The Multiple Factor Theory*

The multiple factor theory received consideration from theorists in the early 1900s due in part to qualitative analyses conducted by Healy (1910). Healy (1910; 1915) noted that delinquents had varied histories and that there did not seem to be any one factor that could be identified as the "cause" of delinquency. Further work on the multiple factor theory was done by Burt (1925) and Elliott and Merrill (1934; 1941). There seemed to be a consensus that persistent criminal behavior was caused by the additive effects of many factors in combination. This idea seems to have been captured by Burt (1925; p. 575), who noted "Crime is assignable to no single universal source, nor yet to two or three: it springs from a wide variety, and usually from a. multiplicity, of alternative, and converging influences. So violent a reaction as may easily be conceived, is almost everywhere the outcome of a concurrence of subversive factors: it needs many coats of pitch to paint a thing thoroughly black."

The conceptual problem with the multiple factor theory was commented on by Sutherland (1934; p. 48), and his thoughts seem to reflect the prevailing view by criminologists. He noted that, "A multiple factor theory is undoubtedly closer to the facts than the earlier theories, but since the quantitative and qualitative relations between the several factors are not known it is unsatisfactory for purposes of understanding, of control, and of prevention."

Sutherland's (1934) position seemed to be the beginning of the end for multiple factor theory. Cohen (1970; p. 78) went on to suggest that the multiple factor theory is the "abdignation of theory." This statement seems to suggest that unless a theory proposes a single cause, it is not a theory.

## *Modern Offender Risk Assessment Practice*

As a point of interest, it should be noted that, although it is not treated in the literature as an outgrowth of multiple factor theory, the multiple factor approach is used on a regular basis in the process of offender risk assessment. Offender risk assessment tools are constructed by adding many variables together from several theoretical orientations in order to improve predictive accuracy (Hart, 1923; Burgess, 1928).

However, even in the risk assessment community, the process of aggregating variables from many theoretical orientations is criticized as "dustbowl empiricism" (Bonta, 1997). Again, the inductive nature of these observations is seen as unscientific.

## *Crimes Take Many Forms*

There appear to be many types of crime. Crime was defined as "individual acts that are perceived by society to be harmful enough to warrant legal sanctions." The types of acts defined as "crimes" vary considerably. The FBI (2013) has developed a classification system for crimes in the U.S. for use with the National Incident Based Reporting System (NIBRS). The crime categories are listed below. The list of categories contains 56 different categories of crime. The FBI (2000) instructions for placing crimes into these categories lists 354 different types of crimes that can be classified into these 56 categories. It seems clear that many different types of behavior are seen to be harmful enough to warrant legal sanctions.

***National Incident Based Reporting System (NIBRS) Crime Codes***

| Code | Description | Code | Description |
|---|---|---|---|
| 09A | Murder/Nonnegligent Manslaughter | 26E | Wire Fraud |
| 09B | Negligent Manslaughter | 270 | Embezzlement |
| 100 | Kidnaping/Abduction | 280 | Stolen Property Offenses |
| 11A | Forcible Rape | 290 | Destruction/Damage/Vandalism of Property |
| 11B | Forcible Sodomy | 35A | Drug/Narcotic Violations |
| 11C | Sexual Assault With An Object | 35B | Drug Equipment Violations |
| 11D | Forcible Fondling | 36A | Incest |
| 120 | Robbery | 36B | Statutory Rape |
| 13A | Aggravated Assault | 370 | Pornography/Obscene Material |
| 13B | Simple Assault | 39A | Betting/Wagering |
| 13C | Intimidation | 39B | Operating/Promoting/Assisting Gambling |
| 200 | Arson | 39C | Gambling Equipment Violations |
| 210 | Extortion/Blackmail | 39D | Sports Tampering |
| 220 | Burglary/Breaking and Entering | 40A | Prostitution |
| 23A | Pocket-picking | 40B | Assisting or Promoting Prostitution |
| 23B | Purse-snatching | 510 | Bribery |
| 23C | Shoplifting | 520 | Weapon Law Violations |
| 23D | Theft From Building | 90A | Bad Checks |
| 23E | Theft From Coin-Operated Machine or Device | 90B | Curfew/Loitering/Vagrancy Violations |
| 23F | Theft From Motor Vehicle | 90C | Disorderly Conduct |
| 23G | Theft of Motor Vehicle Parts/Accessories | 90D | Driving Under the Influence |
| 23H | All Other Larceny | 90E | Drunkenness |
| 240 | Motor Vehicle Theft | 90F | Family Offenses, Nonviolent |
| 250 | Counterfeiting/Forgery | 90G | Liquor Law Violations |
| 26A | False Pretenses/Swindle/Confidence Game | 90H | Peeping Tom |
| 26B | Credit Card/Automatic Teller Machine Fraud | 90I | Runaway |
| 26C | Impersonation | 90J | Trespass of Real Property |
| 26D | Welfare Fraud | 90Z | All Other Offenses |

## *The Many Correlates of Crime*

There would seem to be many correlates of crime. Ellis, Beaver, and Wright (2009) compiled a list of hundreds of the known correlates of crime and criminal behavior. The categories listed include past criminal behavior, demographic factors such as age, gender, race, and social status, ecological factors such as lead levels in the environment, day of the week, and the temperature outside, macro-economic factors, family factors such as number of parents present and parenting practices, peer factors such as number of friends and peer criminality, institutional factors such as school, work, and religious participation, personality factors such as callousness, sensation seeking, and low self-control, behavioral factors such as having many sex partners, and aggressive driving, cognitive factors such as low intelligence, mental illness, mental disorder, and drug addiction, biological factors such as genetics, birth defects, physiology, hormones, and head injury, and past crime victimization. This provides just a brief overview of the factors related to criminal behavior. If you get the book, be sure to request the 276 page supplement with the references to all of the studies they cite.

## *Personality Factors across the Big Five Traits*

Criminal behavior is related to several personality facets, but these facets do not fall exclusively into any of the five major groups of personality factors. The “big five” personality factors are Extraversion, Agreeableness, Conscientiousness, Neuroticism, and Openness to experience. Criminal behavior is correlated with personality constructs in every one of the big five personality factors. This has led to a proposal to develop a sixth personality factor that represents the propensity to commit crimes.

## *Missing Heritability*

Twin studies suggest that about 50% of the variance in criminal behavior can be explained by a person’s genetic makeup. These twin studies are based upon methods that use a person’s entire genome to predict criminal behavior.

However, there is a missing heritability problem. Studies that find individual genes that predict criminal behavior can only explain small amounts of variance. Where is this “missing” heritability?

The solution is simple, if rather unappealing. The logical conclusion is that the phenomenon of missing heritability is due to the probability that many hundreds and possibly thousands of genes affect whether one is more or less prone to criminal behavior. Variation in criminal behavior has many genetic causes.

## *Timing*

Research on the commission of crimes suggests that timing is important. Zamble and Quinzey () found that most crimes are not premeditated. Most crimes are not planned or even thought of 15 minutes before they occur. Crimes tend to emerge from the situation, which is constantly varying.

## *Situation*

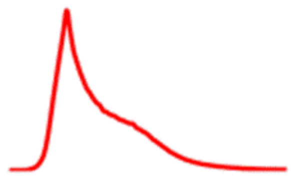
Situational crime theorists point out that crimes do not occur unless the situation is right. A crime will not occur if there is a capable guardian.

## *Putting the Pieces Together*

The conclusion to be drawn from the vast amounts of criminological research is that crimes have an infinite number of causes. The causes are additive, which means that when more factors are present, the odds of a crime increase.

# Chapter 7: Criminal Propensity is Complex

Criminal propensity is complex and has complex dynamics. There are two main sources of these complex dynamics. The first source of dynamic change in criminal propensity is development. The second source of dynamic change in criminal propensity is the dynamic interplay between the person's cognition and the environment.

| | |
|---|---|
|  | Development causes a shift in the rate of crime over the life course. This creates a distinctive curve in the crime rate by age called the "age crime curve" (Farrington, 1986). The peak age of crime in the U.S. age crime curve shown on the left is at about age 18. |
|   | Human behavior has complex and chaotic dynamics. These dynamics are affected by developmental factors and brain function. There is both a measure of continuity and limitless individual variability in the propensity for crime. |

The complex dynamics of criminal propensity are not well understood. There currently is no generally accepted theory to explain the age crime curve, and the reasons for fluctuation in criminal propensity over time have received very little study. The purpose of the following overview is to bring this subject into the criminological discourse.

## *Criminal Propensity Fluctuates*

Criminal propensity fluctuates. The technical term for this type of fluctuation is "intra-individual variation." Intra-individual variation in criminal propensity occurs at all time scales. Criminal propensity fluctuates in milliseconds, seconds, minutes, hours, days, months, years, and decades. Different processes drive the intra-individual variation in criminal propensity at each time scale. This means that the causes of fluctuation are fluctuating. The fluctuation is not constant and levels of intra-individual variation in criminal propensity can vary over time. In essence, there is fluctuation in the levels of fluctuation.

Criminologists have barely scratched the surface in studies of intra-individual variation in criminal propensity. This should not be surprising since the studies of intra-individual variation in other traits in the broader scientific community are very limited. Criminologists have a chance to get in on the ground floor with studies of intra-individual variation.

There is intra-individual variation in every human characteristic. This includes height, weight, intelligence, personality, reaction time, and the list goes on and on. The intra-individual variation in these phenomena is separate from developmental factors, but also intertwined with development. That is, there are developmental influences on levels of intra-individual variation.

Intra-individual variation in criminal propensity can be measured by collecting levels of criminal propensity at several points in time. The technical term for this is "time series." There are excellent measures of criminal propensity being collected in time series in the form of criminal offender risk assessment instruments. There is a huge treasure trove of time series data related to criminal propensity available to criminologists because time series criminal offender risk scores have been collected by many corrections agencies for the past couple of decades.

This chapter is intended to provide an introduction to intra-individual variation in criminal propensity. It is hoped that others may start exploring this phenomena and start getting a better sense of how and why it occurs. A small start in this direction will be provided by a discussion of how brain processes might cause intra-individual variation in criminal propensity. Some of the broader policy implications will also be discussed.

## *A Rose by Any Other Name …*

Intra-individual variation in criminal propensity has been called many names. The following represents a brief review of some of the names for intra-individual variation in criminal propensity. The efforts to describe this phenomenon seem to be largely focused on a qualitative description.

### The Zig-Zag Path from Crime to Noncrime

Glaser (1964) referred to the fluctuation in offending patterns using the term “zig-zag.” After a review of several case studies, Glaser (1984; p. 85) concluded the following.

> What becomes increasingly clear from all of the case studies and statistics on criminal careers presented thus far, or to be cited later, is that almost all criminals follow a zig-zag path. They go from noncrime to crime and to noncrime again. Sometimes this sequence is repeated many times, but sometimes they clearly go to crime only once; sometimes these shifts are for long duration or even permanent, and sometimes they are short lived.
>
> What influences affect these rates of variation? Most important, to what extent can they be altered by government action, in prison or on parole? The rest of this book is concerned with the answers that the latter questions can now receive, and with the methods by which these answers may be improved.

Although Glaser (1964) provides a largely qualitative description of fluctuation in criminal propensity, he points out that this is a phenomena that is worthy of further study.

### Drifting between Criminal and Conventional Action

Matza (1964) referred to the fluctuation in criminal propensity as “drift.” In the introduction to this topic, he used several terms to describe this phenomena (Matza, 1964; p. 28).

> The image of the delinquent I wish to convey is one of drift; an actor neither compelled nor committed to deeds nor freely choosing them; neither different in any simple or fundamental sense from the law abiding, nor the same; conforming to certain traditions in American life while partially unreceptive to other more conventional traditions; and finally, an actor whose motivational system may be explored along lines explicitly commended by classical criminology-his peculiar relation to legal institutions.
>
> The delinquent is casually, intermittently, and transiently immersed in a pattern of illegal action. His investment of affect in the delinquent enterprise is sufficient so as to allow an eliciting of prestige and satisfaction but not so large as to "become more or less unavailable for other lines of action." In point of fact, the delinquent is available even during the period of optimum involvement for many lines of legal and conventional action. Not only is he available but a moment's reflection tells us that, concomitant with his illegal involvement, he actively participates in a wide variety of conventional activity. If commitment implies, as it does, rendering oneself presently and in the future unavailable for other lines of action, then the

> delinquent is uncommitted. He is committed to neither delinquent nor conventional enterprise. Neither, by the canons of his ideology or the makeup of his personality, is precluded.
>
> Drift stands midway between freedom and control. Its basis is an area of the social structure in which control has been loosened, coupled with the abortiveness of adolescent endeavor to organize an autonomous subculture, and thus an independent source of control, around illegal action. The delinquent transiently exists in a limbo between convention and crime, responding in turn to the demands of each, flirting now with one, now the other, but postponing commitment, evading decision. Thus, he drifts between criminal and conventional action.

Matza (1964) is describing criminal behavior as a transient state. Again, this is a qualitative description of something that is observable at the individual level. Criminal propensity appears to be fluctuating over time.

## Intermittency: Somewhere between Persistence and Desistence

Piquero (2004) reviewed the topic of fluctuation in offending and chose to focus on the term "intermittency." He looked at fluctuation in offending in terms of the criminal career pattern and the topic of desistance. Piquero (2004; p. 117) proposed several questions about intermittency that researchers might try to answer.

1. Does intermittency increase or decrease with time?
2. Do local life circumstances (i.e. wife, school, job) relate 10 intermittency patterns?
3. Arc intermittency periods longer for violent crimes as opposed to non-violent crimes?
4. Is there within-individual variability in how intermittent periods vary across types of crime?
5. Do different types of offenders evidence different intermittency patterns?
6. Are intermittency patterns influenced by alcohol and/or drug use and abuse?
7. Do groups defined by race and sex evidence different intermittency patterns?
8. How do correctional and policy responses influence subsequent intermittency patterns?
9. Do various treatments and interventions influence subsequent intermittency patterns?

These questions provide a basis for studying the phenomenon of intra-individual variation in criminal propensity.

### An Example of Intra-Individual Variation

It is likely that anyone who has observed individual time series trajectories has observed "intra-individual variation" in whatever is being measured. Human characteristics fluctuate. This is true whether one is talking about height, weight, intelligence, personality, health, or any other human characteristic. These fluctuations occur at time scales from the micro-second to the lifetime. There is surprisingly little literature on this topic. The reasons for the lack of scientific study in this area are not clear, but it seems clear that this is a very difficult topic to study.

### Fluctuation in Criminal Propensity

The point of these discussions is that criminal propensity fluctuates. There are two sources of fluctuation. The first is fluctuation that occurs because of human development, and the second type of fluctuation occurs for other reasons.

*Developmental Fluctuation: The Age Crime Curve*

Quetelet (1833/1984) found that criminal propensity is fluctuating over the life course. Farrington (1986) proposed the term "age-crime curve" to explain this pattern. The age crime curve indicates that crimes are most likely in late adolescence and early adulthood.

Since this topic will be covered in its own chapter, little attention will be paid to it here. The point to be made is that criminal propensity is changing over the life course.

**The Age Crime Curve**

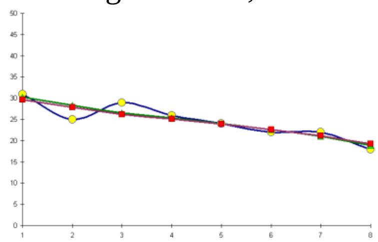
*Intra-Individual Variation*

The second type of fluctuation is intra-individual variation. An examination of criminal offender risk scores reveals that the risk scores are fluctuating over time. Furthermore, these fluctuations do not follow any specific pattern.

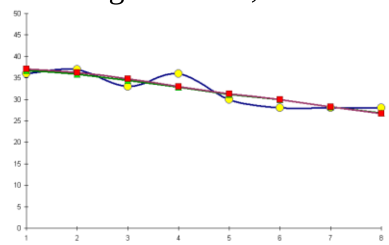
I obtained a set of risk assessment scores with measurements that were taken at about six month intervals. These scores were obtained using the level of Service Inventory-Revised (LSI-R; Andrews & Bonta, 1995). There were 12 offenders with eight scores. I plotted each set of eight risk assessment scores along with a linear trend from assessments 1-8 and 2-8. Note that there is random fluctuation in criminal propensity that does not follow any particular pattern.

**Twelve Criminal Offender Risk Plots**

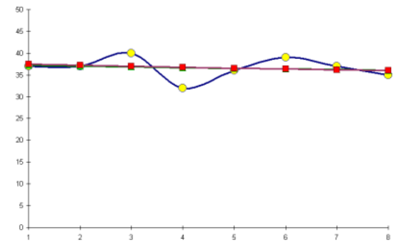
Plot 1: Sig. Dec. 1-8, & 2-8



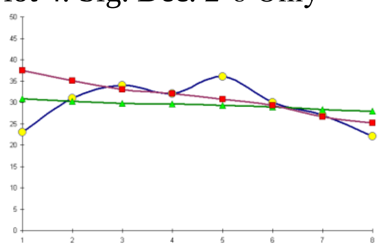
Plot 2: Sig. Dec. 1-8, & 2-8



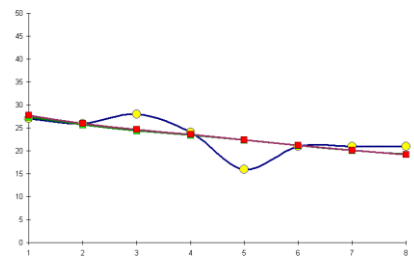
Plot 3: NS OLS Trend



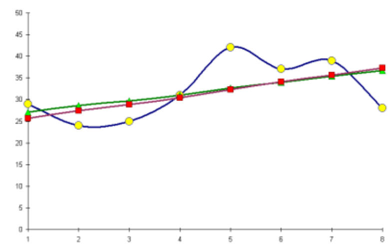
Plot 4: Sig. Dec. 2-8 Only



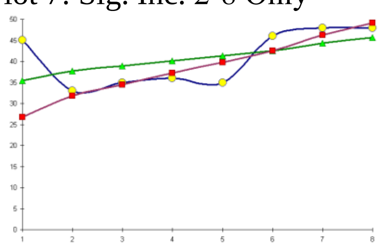
Plot 5: NS OLS Trend



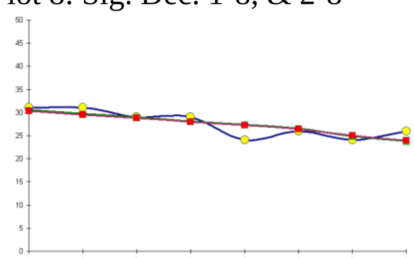
Plot 6: NS OLS Trend



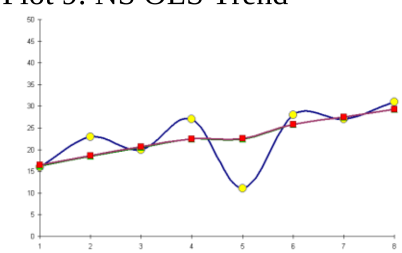
Plot 7: Sig. Inc. 2-8 Only



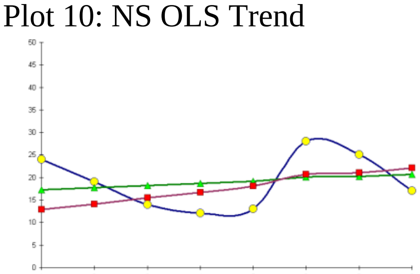
Plot 8: Sig. Dec. 1-8, & 2-8



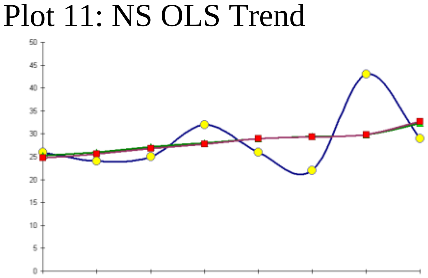
Plot 9: NS OLS Trend



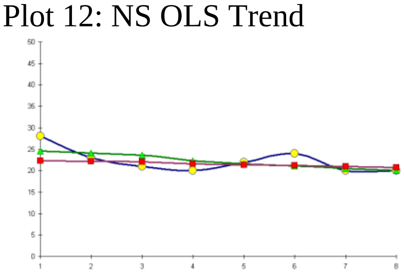
Plot 10: NS OLS Trend



Plot 11: NS OLS Trend



Plot 12: NS OLS Trend



# Chapter 8: Criminal Propensity is Normally Distributed

There does not seem to be much opposition to the proposition that criminal propensity is normally distributed, but there does not seem to be much interest in this idea either. The response toward the proposition that criminal propensity is normally distributed seems to be more apathetic than anything else. Very few people seem to be going out of their way to actively promote the idea that criminal propensity is normally distributed. It is suggested that this is an oversight that should be corrected. It will be suggested that understanding the nature of the propensity for crime should be one of the most important tasks for criminologists.

## *Quetelet and the Law of Accidental Causes*

Quetelet appears to be the first person to suggest that crime is normal. His work should be at the forefront of any discussions in this area. Unfortunately, much of his relevant work in this area has not been translated into English. I have tried to create some crude translations using Google Translate, and one of these translations is in Appendix B. I call upon some of our French speaking colleagues to try to bring this man's work to our English speaking criminologists.

Quetelet (1831; 1833/1984) began by examining crime rates in France. He found that criminal propensity varied by age, gender, time of year, reading ability, and section of the country. One of the more startling findings was that crime rates were relatively constant. He proposed a crime budget, where a certain number of murders, rapes, thefts, etc. had to be committed each year. This idea seemed to generate considerable criticism, since he was defending this proposition two years later (Quetelet, 1835).

Quetelet was working at a time when much of our current understanding of human characteristics had not been developed. Quetelet spent considerable time developing a set of ideas and methods for conceptualizing and measuring various facets of the physical, mental, and moral world. One of his first contributions was the concept of the "average man."

### The "Average Man" and an Attempt to Create a Science of Social Mechanics

Qutelet (1831; 1833/1984) began with the idea that we should study the "average man" and attempt to build a social mechanics that was similar to the work on celestial mechanics. This is a somewhat different concept from our current scientific model, but it is an important piece of the criminological puzzle. He envisioned an exact science of social mechanics that was similar to the law of physics.

Quetelet (1833/1984; pp. 3-4) wrote,

> I have tried to indicate in a former *Memoire* of what importance observations would be which would have as their aim the study of the several components relating to man, either as regards physical or mental and moral qualities, and of the laws which these components follow in their development from birth to the grave.
>
> The man which I considered is in society the analogue of the center of gravity in matter. He is a fictional being in regard to which all things happen in accordance with average results obtained for society. If the *average* man were ascertained for one nation, he would present the type of that nation. If he could be ascertained according to the mass of men, he would present the type of the human species altogether.
>
> In being restricted to ascertaining the average man for one nation and studying him in a consistent way, one can judge the changes which he experiences because of the times, and recognize if these

> changes result from nature or from man who, in the social state, reacts on himself by virtue of certain forces which he has at his command from his free will.
>
> In admitting that these forces actually exist, as all observations appear to prove, I call them disturbing forces of man by analogy with the *disturbing forces* which scientists have considered in the system of the universe. One imagines that the effects which result from them act with such slowness that they could be called equally by analogy *secular disturbances*. The science which would have such a study as a goal would be a veritable *social mechanics*, which, no doubt, would present laws quite as admirable as the mechanics of inanimate objects, and would bring to light the conservative principles which perhaps would be only the analogies of those we already know.
>
> This way of looking at the social system has something positive about it which must, at first, frighten certain minds. Some will see in it a tendency to materialism. Others, in interpreting my ideas badly, will find there an exaggerated pretention to aggrandize the domain of the exact sciences and to place the geometrician in an element which is not his own. They will reproach me for becoming involved in absurd speculations while being occupied with things which are not susceptible to being measured.

In proposing an exact science, he is suggesting that the study of human phenomena begin with the average person and build upon those data to create a social mechanics. As he noted, this idea may "frighten certain minds." The idea that there are laws of nature that are similar to the laws of physics seems foreign to individual difference research. We seem to be more comfortable with a fuzzy science than an exact science. Yet, Quetelet seemed to be convinced that an exact science should be possible. Quetelet (1833/1984; p. 5) argued,

> After having seen the progress which the sciences have pursued in regard to universes, are we not able to try to pursue it in regard to men? Would it not be absurd to believe that, while all happens according to such admirable laws, the human species alone remains blindly neglected by itself, and that it possesses no principle at all of conservation? We are not afraid to say that such a supposition would be more offensive to the divinity than the very research which we intend to do.

Upon reflection, his arguments seem to be prescient. Work on an exact science of social mechanics seems to have been replaced by a science of the individual. The focus in many scientific efforts is on micro science rather than a macro science of social mechanics.

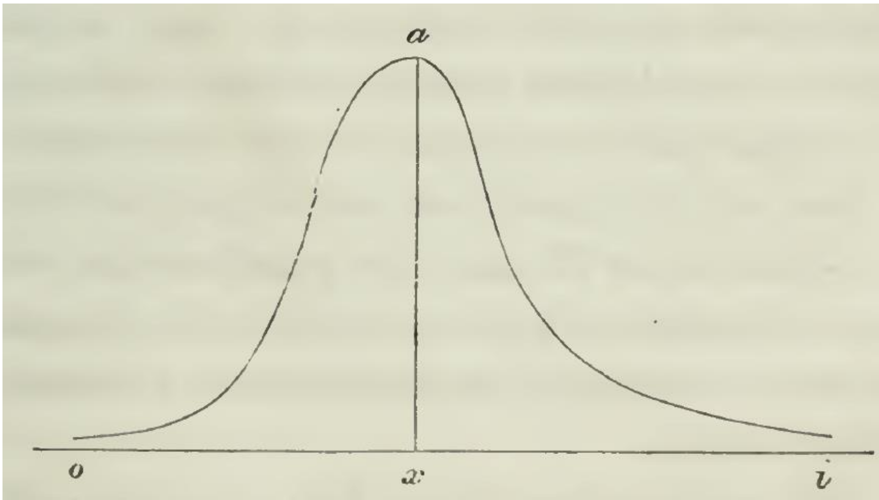
## *Criminal Propensity is Normally Distributed*

Quetelet (1848) went on to study many human characteristics. Among these characteristics was the propensity for crime. Quetelet proposed that the propensity for crime followed the law of accidental causes. The phrase "law of accidental causes" translates literally to "normally distributed." This is illustrated by his comments and illustration which are included in their entirety in Appendix B. The reader is encouraged to read the whole chapter.

The excerpt from Quetelet (1848; pp. 93-94) illustrates this point.

> Suppose that attention is fixed on all men 30 years. We conceive that there is in each of them, a certain possibility, (word tendency would say too much perhaps about it) to get in hostility with the laws. This possibility, however small it is, admits of the lower levels until it can be absolutely void; as well, it can grow up to become equal to certainty. Thus, some men certainly will not conflict with the law; while, in others, on the contrary, the opposition will manifest. The other

men in greater numbers, will approach more or less than average; the following figure will be able to make this distribution more sensitive to the eyes.




At the point o, the likelihood of crime, addiction or crime, is absolutely nil. The likelihood increases as one moves away

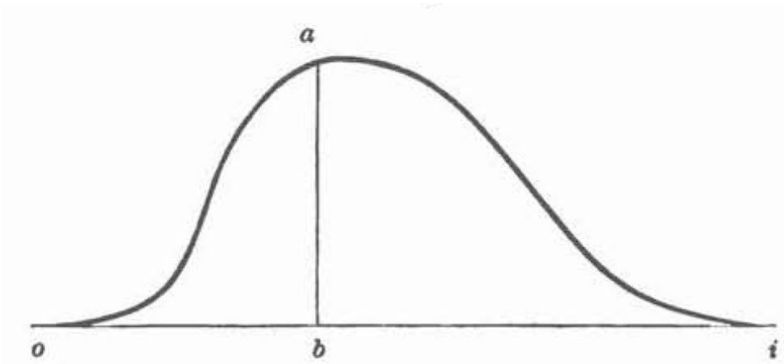
Page 94

to move to the right, and it becomes certainty to i. The curved line oai by its deviations from the straight line oi, shows the number of people corresponding to each probability.

The same oai line, which discloses how men distribute themselves among them, in point of propensity to crime, affects, again, the shape of the curve accidental causes. It should be noted that we find, for the moral qualities, the same law that regulates the distribution of men in the relationship of elevated height, body weight, strength and other physical attributes. I must warn, however, that I am not presenting this result as deduced directly observed facts; I even think that it will never be possible to demonstrate anything in this regard, other than by way of induction.

Quetelet (1869; pp. 332-333) repeated his arguments with a slightly different discussion. In these later comments, he points out that the distribution of propensity is age related.

In summary, it is understandable that there is in all men a certain possibility of hostility to the laws and engage in any wrongdoing. This possibility, however small it may be, admits to lower levels can become absolutely void, as it can also grow, in some, to become equal to certainty. Thus, on the one hand, some citizens will certainly will not conflict with the laws, while the other, on the contrary, the opposition will manifest no doubt. Other citizens in greater numbers, approach more or less of the former. The following illustration will make this distribution to sensitive eyes.




Likelihood of crime and number of criminals

> At point *o*, the probability of crime is absolutely zero. This probability increases as one moves away from point *o*, to advance to the point *i*, where it is converted into certainty. The curved line *oai*, by the extent of its deviations from the straight line *oi*, indicates the number of criminals corresponding to each probability.
>
> Thus, the maximum number represented by the ordinate *ab*, has on its side *ob* the probability of committing a crime.
>
> Young children, and unfortunately very few adults, are at the point *o* or in its vicinity, without thinking of the crime. This thought grows with age and men grow to the point of some perverse minds. If the curve falls after point a, this is without doubt because the man is getting better, but because that the number of criminals is diminishing with age, forming a digital maximum ba, however far removed from the maximum crime i, which can only exist in some perverse minds. If the curve falls after point a, this is without doubt because the man is getting better, but because that the number of criminals is diminishing with age.

Note that Quetelet's (1869) statement on probability of crime is incorrect. He states, "Thus, the maximum number represented by the ordinate ab, has on its side ob the probability of committing a crime." The actual probability is the area under the curve to the left of ab. This will be addressed in a later chapter.

The primary point of this discussion is that Quetelet (1848; 1869) was proposing that the propensity for crime was normally distributed. It does not appear that anyone took this seriously.

## Durkheim's (1895) Crime is Normal

Durkheim (1895) suggested that crime is normal. He argued that the types of activities that can be thought of as "crime" vary from the most to the least serious.

## Allport's (1934) J-Curve Hypothesis of Conforming Behavior

Allport's (1934) attempts to find a behavioral distribution deserve mention. Allport (1934) looked at a number of situations where conformity might be a motivating factor. For example, he examined the frequencies of behaviors in church or numbers of people stopping at a stop sign vs. rolling through without stopping. He noted that the modal behavior was conformity. There were successively less and less people with behaviors that violated the norms at increasing levels of norm violation. For example, few people drove through the stop sign at high speed.

The reader who is interested in this idea is encouraged to read the article. Later on in the chapter, it will be demonstrated that Allport's (1934) data is consistent with a Poisson distribution, which is consistent with a normally distributed trait.

## Cavan's (1961) Behavior Continuum

Cavan (1961) discusses the possibility that the propensity for conformity is normal. She points to Allport's (1934) work as evidence to support this hypothesis. Cavan (1961; pp. 244-246) wrote,

> A word now about Figure 1. The figure represents the social structure, the framework of which consists of the institutions and less formal but fairly permanent organizations that, operating together, carry on the functions of the society. Area D represents the central or dominant part of the social structure, where institutions are found that set the formal standards for behavior and exert the formal means of control. The base line represents the extent of deviations from the central social norms. According to this hypothetical formulation, behavior falls into a continuum from condemnable behavior (area A) through decreasing degrees of disapproved behavior to the central area D and then through increasing degrees of good behavior to near perfection in area G.
>
> The area above the line represents the volume of behavior-or more concretely the number of people-that falls into the area con-

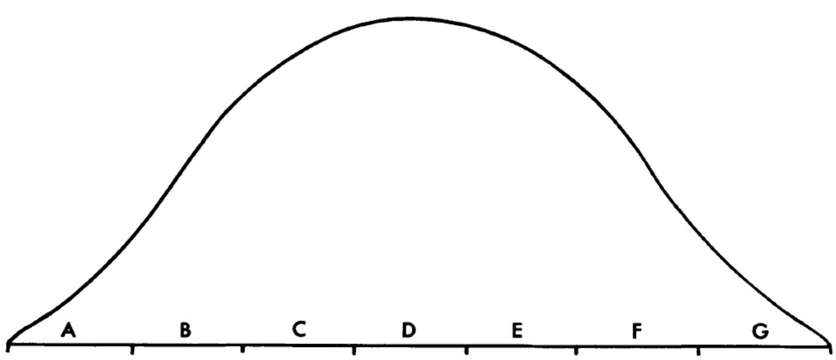



FIGURE 1. Hypothetical formulation of behavior continuum

A. Underconforming contraculture
B. Extreme under-conformity
C. Minor under conformity
D. Normal conformity
E. Minor over-conformity
F. Extreme over-conformity
G. Over conforming conformity

trolled by the norms and into successive segments of deviation. There is sufficient evidence, that I will not quote, to support a bellshaped curve.[2]

> [2] Floyd H. Allport, "The J-Curve Hypothesis of Conforming Behavior," Journal of Social Psychology, 5:141-83 (1934); R. T. LaPiere, and P. R. Farnsworth, Social Psychology (McGraw-Hill: New York, 1936), p. 400.

Even though we know that behavior falls into a continuum, nevertheless we tend to think in terms of dichotomies. We have the sinner and the saint, the devil and the angel, the alcoholic and the teetotaller, the criminal and the upright citizen, the juvenile delinquent and the model child. We tend to think in terms of black and white, whereas between these two rare extremes are many shades of gray.

### Wilkin's (1969) Saints and Sinners

## A Theory of Infinite Causes

The contention that the multiple factor approach is not a theory seems to ignore the meaning of theory. To illustrate this, it will be helpful to return again to Reynolds (1971) five goals of theory.

(1) A method of organizing and categorizing "things," a typology;
(2) Predictions of future events;
(3) Explanations of past events;
(4) A sense of understanding about what causes events.
(5) The potential for control of events.

The multiple factor approach is not a typology, but it meets the other four criteria of a theory. Note that theories of intelligence propose that there are multiple factors that affect whether one is intelligent or not, and the theories of intelligence are not considered "non-theories."

### Many Causes Working Together

It seems clear that there are an almost limitless number of factors associated with criminal behavior. Consider that the FBI lists over 50 different types of crime. It seems logical that each of these various behaviors is due, at least in part, to different causes. Robinson (2002) suggested that criminal behavior is related to factors at the cellular, organ, individual, group, community, and societal levels of analysis. His analysis left out environmental and situational factors. Ellis, Beaver, and Wright (2009) catalogued hundreds of factors in many different areas of study that are related to crime. Agnew and Cullen (2010) list fifty different theoretical articles as "essential reading" and suggest that many theoretical orientations were left out to get the number down to fifty. Finally, the missing heritability problem suggests that crime is "polygenic" and many individual genes are related to criminal behavior. It seems clear that crime is a function of limitless numbers of variables as suggested by Equation 1.

$$Crime = f(X_1, X_2, X_3, \dots, \mathrm{X}_\infty) \qquad \text{Equation 1}$$

# Criminal Propensity is Normal

Although the proposition that crime has a limitless number of causes initially seems to lead to a theoretical dead end, the concept of a massively multivariate phenomenon leads directly to the proposition that criminal propensity is a normally distributed latent trait. The reason for this is because of the central limit theorem. The central limit theorem tells us that whenever some phenomenon is the result of many independent factors, that phenomenon must be normally distributed. Since the propensity to harm others appears to be the result of many different causes, the propensity to harm others must be normally distributed.

The Central Limit Theorem

The central limit theorem was initially developed to help gamblers determine the odds of winning in games of chance. De Moive (1733) appears to have been the first to note that repeated chance events tend to create a frequency distribution that approximates what we now think of as the normal distribution, or bell curve. Others such as Gauss and LaPlace provided further treatment of this idea. The central limit theorem was used to plot the distribution of errors in sample selection.

Adolph Quetelet appears to be the first to suggest that criminal propensity was normally distributed. After examining annual crime rate data from France, Quetelet (1833/1984) noted that crime rates are almost constant over time and that certain levels of crime seemed to be almost guaranteed. This proposition seemed to imply that crimes might be the result of chance events, and that idea did not appear to be very popular. Quetelet (1835) was defending his position regarding the constancy of crime a few years later. He argued that if the causes of crime are not changing, the crime rate must remain constant. Quetelet (1848; 1869) went on to suggest that the propensity for crime was distributed according to the law of accidental errors. In essence, he argued that the propensity for crime was normally distributed. This model did not seem to get much attention. Perhaps this is due to the works being French and not being translated into English. I have some crude English translations of Quetelet's (1848; 1869) works that I created using Google Translate. If anyone speaks French and English and wants to help clean these up, I suggest that these translations need to make in into the English criminological literature.

Since Quetelet's (1848; 1869) early work, the proposition that criminal propensity is normally distributed has not gained much traction. There are a few theorists and researchers that have addressed this issue in recent years. Cavan (1962) and Wilkins both proposed that the propensity for crime was normally distributed. Rowe, Osgood, and Nicewander (1990) used a custom software program to show that crime rate patterns appear to be caused by a normally distributed latent trait. Clarke (1996), Clarke and Weisburd (1990) and Wikstrom () provide some limited evidence in support of the proposition that criminal propensity is normally distributed. Other than these few references, there does not seem to be much discussion of the proposition that criminal propensity is subject to the laws of chance events and is normally distributed.

It will be proposed that because of the massively multivariate nature of the propensity for crime, the criminal propensity of any reasonably sized group of individuals "must" be normally distributed. There would seem to be little doubt about this. The question is, so what? Why is this important? It is suggested that the proposition that criminal propensity is a normally distributed latent trait will turn out to be the key to solving many criminological conundrums and paradoxes.

## The Propensity Distribution Formulas

The normal probability density function (PDF) is presented in Equation 3. The probability of a person having a particular propensity to harm others (P) given a propensity distribution with mean (μ), standard deviation (σ), and variance ($\sigma^2$) is defined by an exponential function with a negative squared exponent.

$$f(P|u,\sigma) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-(P-\mu)^2}{2\sigma^2}} \qquad \text{Equation 3}$$

If the mean is zero and the standard deviation is one, the result is a standard normal PDF, which can be plotted using the formula presented in Equation 4.

$$\phi(P) = f(P|u = 0, \sigma = 1) = \frac{1}{\sqrt{2\pi}} e^{\frac{-P^2}{2}} \qquad \text{Equation 4}$$

The general form of the normal PDF of the propensity (P) in a distribution with mean (μ), standard deviation (σ), and variance ($\sigma^2$) can be expressed in terms of the standard normal PDF with the formula in Equation 5.

$$f(P|u,\sigma) = \frac{1}{\sigma}\phi(\frac{(P-\mu)}{\sigma}) \qquad \text{Equation 5}$$

The general form of the normal PDF can be simplified by subtracting the mean from P, and dividing the result by the standard deviation. The simplified result is called a “Z score,” which indicates a variable with a unit standard deviation. The transformation from P, μ, and σ to a Z score is shown in Equation 6.

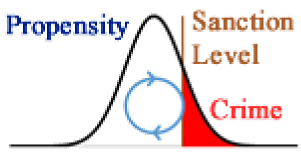
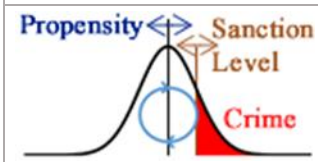
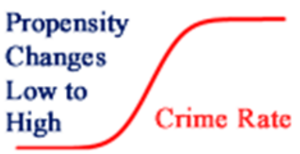
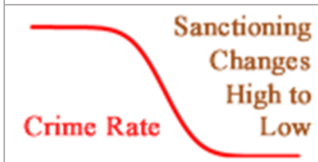
$$Z = (P - \mu)/\sigma \qquad \text{Equation 6}$$

The normal PDF of the propensity distribution can then be determined by using the Z transformation. Note that the standard normal PDF must be divided by the standard deviation of the propensity distribution to convert to the general normal PDF as shown in Equation 7.

$$f(P|u,\sigma) = \frac{1}{\sigma}\phi(Z) \qquad \text{Equation 7}$$

It is suggested that the MMCaN model is a useful tool for modeling criminal propensity.

# Section 2B: Sanctioning and Crime Rates

<table>
<tr><td colspan="2">Societal Sanctioning is an Asymmetric Selection Process Creating a Threshold Effect</td></tr>
<tr><td><br></td><td>Societies sanction only a small fraction of the population for criminal behavior. This fraction tends to be comprised of individuals who are found on one side of the criminal propensity distribution. The process of sanctioning is probabilistic and cumulative in nature. The crime rate is the area under the propensity curve to the right of the sanctioning level.</td></tr>
<tr><td colspan="2">Change in Propensity or Sanctioning Causes Sigmoid Changes in the Crime Rate</td></tr>
<tr><td><br></td><td rowspan="3">The level of criminal propensity follows a normal probability distribution function (PDF). The sanctioning process is an asymmetric selection process, which creates a threshold effect. When asymmetric selection occurs in a normal PDF, the resulting cumulative distribution function (CDF) is a sigmoid curve.<br><br>Crime rates are CDFs that indicate the probability of crime, given a particular propensity PDF, after a set amount of selection has occurred. The change in the CDF is dependent upon changes in either the mean propensity level or the selection level. The process with a change in either factor is shown on the left.</td></tr>
<tr><td><br></td></tr>
<tr><td><br></td></tr>
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# Chapter 9: Sanctioning is an Asymmetric Selection Process

The next step is to propose that sanctioning is a cumulative asymmetric threshold process. The sanction process is 1) cumulative, 2) asymmetric, and 3) similar to a threshold.

It is suggested that the sanctioning process is cumulative and occurs over the space of time. The police are working 24/7 to impose sanctions on those who harm others. The "crime rate" is the sum of all of the crimes that were sanctioned in a particular length of time. Usually, crime rates are expressed in crimes per year. Sanctioning is a cumulative process.

It is suggested that the sanctioning process is asymmetric. That is to say, only the most harmful acts are sanctioned. It is proposed that the various legislatures, police, and courts are trying to sanction people on one end of the criminal propensity distribution. People who mind their own business and do not bother anyone will tend to be sanctioned less than someone who is shooting people in a bar. Therefore, the people on the high end of the propensity distribution are most likely to be sanctioned first.

It will be suggested that the sanctioning process is a threshold process. It is suggested that there is a "line in the sand" that people cannot cross without expecting to be sanctioned. People who perform actions that exceed some defined level of perceived harm are sanctioned while people who do not exceed that level are not sanctioned. While the line may be blurry, one can envision its presence.

While these points may seem trivial, they are important precursors to the next step in the modeling process. Probably the weakest point in the suggested model is the proposition that there is a sharp sanctioning threshold. It would seem that the sanctioning threshold might be fairly broad. Using Durkheim's arguments, sanctioning is normal, which does not suggest a sharp sanctioning threshold. For the discussions that follow, a sharp sanctioning threshold line will be proposed. This proposition may need to be revisited in the future.

There are a few people who have suggested that there is a threshold relationship between propensity and sanctioning. Quetelet (1848; 1869) noted that criminal behavior was subject to the laws of normal error, and that there was a threshold. Wilkins (1965) proposed a similar model. There is a threshold model of schizophrenia.

## The Calculus of Asymmetric Selection Processes

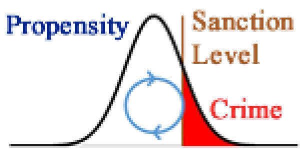
The crime rate is the number of crimes divided by the number of people in the population (N). Usually, the crime rate is calculated for some standard period of time such as a one year interval. If we assume that a person committing a crime is removed from the population so there is only one crime per person, and that N is large with respect to the crime rate, the probability that a person in the population will be sanctioned ($p_{Crime}$) in the standard time period can be estimated to be the same as the crime rate. This is formula shown in Equation 8.

$$p_{Crime} = Crimes\ Committed/N = Crime\ Rate \qquad \text{Equation 8}$$

If we take the proposition that the crime rate is a function of both the propensity to harm and the likelihood of sanctioning, add to that the proposition the propensity for harming others is normally distributed, and add to that the proposition that sanctioning is a cumulative asymmetric threshold process, the formula for the crime rate in given a population with a propensity of mean (μ), standard deviation (σ), and variance ($\sigma^2$), and people with a propensity greater than the sanction level (S) are sanctioned, the propensity for crime in terms of the crime rate should be defined by the cumulative distribution function (CDF) for a normal distribution as shown in Equation 9.

$$Cime\ Rate = F([P|\mu, \sigma], S) = \frac{1}{\sigma\sqrt{2\pi}} \int_{S}^{\infty} e^{\frac{-(P-\mu)^2}{2\sigma^2}} dP \qquad \text{Equation 9}$$

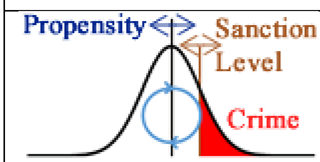
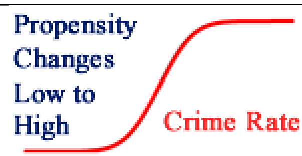
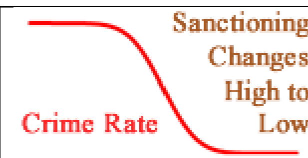
This formula may not seem to be useful at this point, but this function has some interesting properties that should be considered. In particular, it will be demonstrated that crime rates must have "nonlinear dynamics." The properties of this relationship will be discussed in the next section.

| Societal Sanctioning is an Asymmetric Threshold Process | |
|---|---|
|  | Societies sanction only a small fraction of the population for criminal behavior. This fraction tends to be comprised of individuals who are found on one side of the criminal propensity distribution. The process of sanctioning is probabilistic and cumulative in nature. The crime rate is the area under the propensity curve to the right of the sanctioning level. |

# Chapter 10: Crime Rates are Sigmoid

This next step in the model may not seem to be immediately obvious. Why would crime rates follow a sigmoid response curve? The results flow from equation 9. A change in the mean propensity (μ), or a change in the sanctioning level (S), creates a sigmoid response curve. The reason for this is because propensity has a normal probability distribution function (PDF), sanctioning provides an asymmetric selection process, and therefore the crime rate follows a normal cumulative distribution function (CDF). The CDF for a normal PDF is a sigmoid curve.

**Crime Rates Follow a Nonlinear Sigmoid Response Curve with Changes in Propensity or Sanctioning**

| Propensity and Sanctioning Change | The Nonlinear Dynamics of the Crime Rate | |
|---|---|---|
|  |  |  |

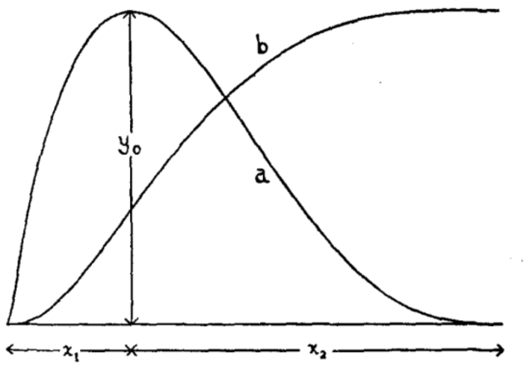
The discussions of the normal CDF model in the scientific literature are sparse. However, there are models that are similar that have received much more attention from theorists. In particular, it is suggested that the mathematical characteristics of the criminal sanctioning process are similar to a mathematical model used to predict how many germs in a petri dish will be killed by various strength antiseptic solutions. It appears that there are some important similarities in the mathematical relationship between the process of killing germs with antiseptics and the process of sanctioning people who harm others.

## Brooks' (1918) Article

Brooks (1918) appears to be one of the first people to recognize that asymmetric selection from a population with a bell shaped distribution will result in a sigmoid response curve. His work grew out of a problem that microbiologists in the early 1900s were struggling with. If antiseptic solutions of various strengths were applied to a number of similar germ samples, the germ death rate would follow a sigmoid response curve. Brooks (1918) reasoned that if the resistance to the antiseptic were a bell shaped curve, and all of the germs with a resistance below a certain threshold are killed, then the kill rate will follow a sigmoid response curve.

Brooks (1918) proposed that the reason for the sigmoid curve was that the underlying distribution of susceptibility to antiseptics was bell shaped. Therefore, using calculus, one could plot the curve, or vice versa, one could find the nature of the probability distribution creating the curve. The probability of cell death at any point would be the area under the curve to one side of a threshold.

**Brooks' (1918) Model**




## What do Germs and Criminals Have in Common?

Now, the reader may well ask, "what do germs and criminals have in common?" It is suggested that the process of sanctioning harmful actions is similar to the process as the process of applying antiseptics to germ samples. Like the resistance to antiseptics, criminal propensity has a bell shaped distribution. Like the antiseptic process of killing the least resistant germs first, people with the highest criminal propensity will tend to be sanctioned first. Therefore, if propensity is normal, and sanctioning is asymmetric, the crime rate will follow a sigmoid normal response curve with changes in the sanctioning level.

Looking ahead to the next section, we find that both propensity and sanctioning might vary. It will be demonstrated that there are four cases that criminologists should look for. These cases depend on whether there is change and/or non-change in either propensity or sanctioning. The case determines whether there will be a sigmoid response in the crime rates.

Therefore, in the model shown below, changes in propensity or sanctioning are projected to cause the crime rate to have nonlinear sigmoid dynamics.

# Section 3: Method

# Chapter 11: The Quantile Transformation

The nonlinear nature of crime rates can cause a considerable problem in creating models. Squared exponential models are very difficult to use. The proposed solution is to consider the quantile function. The quantile function provides the probability that would create a particular Z score. It may not seem to be immediately obvious, but the quantile function will make it much easier to model the relationship between propensity, sanctioning, and crime rates. The quantile function provides a simple way to convert from probabilities to standard deviations and back again.

The discussion that follow move beyond Equation 9, which provided a basic mathematical model of normal distributions. This is a good place to start, but it will be helpful to take a closer look at the intricacies of a nonlinear propensity/sanctioning/crime rate model.

The standard normal CDF is denoted using the capital Greek letter Phi (Φ). The expression for the standard normal CDF for the propensity distribution (P) is $\Phi(P)$. The standard normal CDF is defined as the probability when the mean of a normal CDF is zero and the standard deviation is one. The standard normal CDF for propensity (P) can be derived from Equation 9 by setting $\mu = 0$, and $\sigma = 1$, with the result shown in Equation 10.

$$\Phi(P) = F([P|\mu = 0, \sigma = 1], S) = \frac{1}{\sqrt{2\pi}} \int_S^\infty e^{\frac{-(P)^2}{2}} dP \qquad \text{Equation 10}$$

The calculations involved in finding the relationship between propensity, sanctioning, and crime would be simpler if the crime rate formula could be converted to a function in terms of the standard normal CDF. The transformation used in Equation 6 could be used with the propensity CDF to calculate a Z score transformation. This formula is repeated in Equation 11.

$$Z = (P - \mu)/\sigma \qquad \text{Equation 11}$$

The question is, where does the sanction level fit in the newly transformed model? If it is assumed that the sanction level must be transformed to a Z score using the same transformation that was used to transform the propensity. The formula for the sanction threshold (S) should be given by Equation 12.

$$S = \mu + \sigma Z_S \qquad \text{Equation 12}$$

The next step is to consider the relationship between the crime rate and the sanction level. The value of $Z_S$ can be calculated from the crime rate by using the quantile function. The standard normal quantile function can be thought of as the inverse of the standard normal CDF, and is represented by is a capital Phi raised to the negative one exponent ($\Phi^{-1}$). With the quantile function, if one knows the probability ($p$) of an occurrence, one can find the Z score that would create that probability. This means that $Z_S$ can be calculated using the quantile function, or inverse CDF, of the crime rate. The quantile function provides the sanction level in terms of propensity standard deviation units.

$$Z_S = \Phi^{-1}(Crime\ Rate) \qquad \text{Equation 13}$$

If we plug the value of $Z_S$ obtained in Equation 13 into the formula for the sanction threshold in Equation 12, we can estimate the relationship between the sanction threshold and the crime rate in terms of the propensity mean and standard deviation and the quantile of the crime rate as shown in Equation 14.

$$S = \mu + \sigma\Phi^{-1}(Crime\ Rate) \qquad \text{Equation 14}$$

Now, recall that the crime rate is the probability of crime and that this can range from 0 to 1. In reality, the quantile of the crime rate can range from minus infinity to plus infinity, but the actual values rarely shift beyond plus or minus five standard deviations from the mean. So, if the distributions for cases two and three from above are considered, the following two models are possible.

To simplify the math, we will assume that the standard deviation is equal to one. If the standard deviation is one, the relationship between the sanction level (S), the mean propensity ($\mu_P$) and $Z_S$ as specified in Equation 12 is provided by Equation 15.

$$S = \mu_P + Z_S \qquad \text{Equation 15}$$

This equation provides a simple relationship between propensity, sanctioning, and crime. When the standard deviation is set to one, the quantile of the crime rate [$\Phi^{-1}(Crime\ Rate)$] is equal to $Z_S$, and $Z_S$ is equal to the sanction level (S) minus the mean propensity ($\mu_P$) as shown in Equation 16.

$$Z_S = S - \mu_P \qquad \text{Equation 16}$$

The goal of the preceding chapters was to develop the concepts required to work with normally distributed traits in situations where asymmetric selection processes are occurring. Recall that the theory proposed contained three assumptions.

1. Criminal propensity is massively multivariate, complex, and normal
2. Sanctioning is an asymmetric selection process
3. Crime rates follow a sigmoid response curve with changes in propensity or sanctioning

In general, when faced with a table of crime rates, one has to determine whether the rates fit this three part sigmoid model. There are a number of methods for doing so. These vary in level of difficulty, and so it is suggested that you work from the simplest to the more complex. The basic problem is in working with sigmoid response curves. Once this hurdle is overcome, the process gets much easier.

## Is the Plot Sigmoid?

Imagine that you are comparing a set of rates. These rates could be crime rates for various countries or crime rates for various groups. You suspect that the underlying cause is normally distributed and that there is an asymmetric selection process. The first question that must be answered is whether the plot is sigmoid. The easy way to answer this question is to use the method of probits.

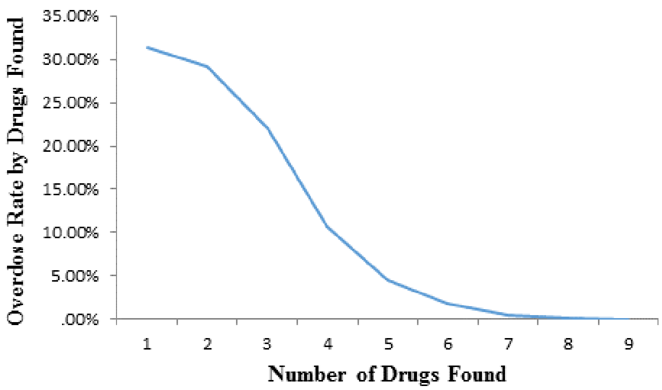
### *The Method of Probits*

The method of probits developed by Bliss (1934; 1935) provides a quick method for converting sigmoid rates to a plot that can be observed in linear standard deviation units. To calculate the probit, simply calculate the quantile from the rate and add 5. Since the quantile is simply the standard normal Z score, this is easily done in Excel. If the Z score plot is a straight line, the original rate plot is probably some form of sigmoid curve.

#### An Example of Probit Plotting

I am working to determine whether there is a relationship between the number of drugs taken and the chance of fatal overdose. Evidence suggests that risk of fatal overdose increases with the number of drugs taken. I have collected data on death rates by numbers of drugs found. Is this a sigmoid process?

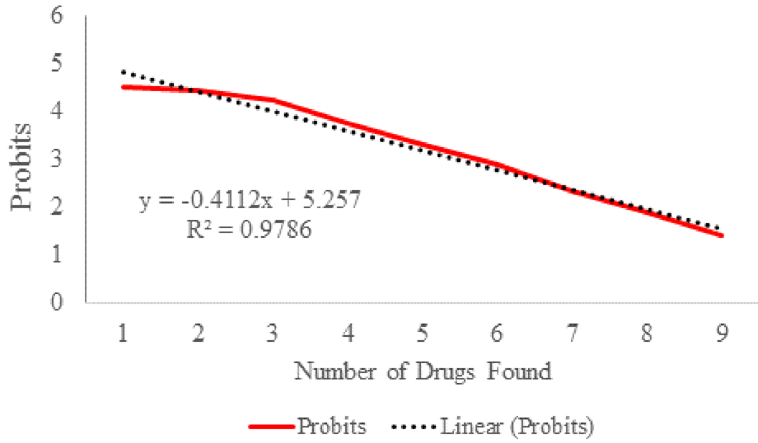
A plot of the rate of death by overdose by the number of drugs found suggests that this could be a sigmoid curve. The plot appears to be somewhat "S" shaped. Is this plot sigmoid?




The first step is to calculate the rates and then the probits. This was done in Excel. The formula used is the Norm.S.Inv formula, which takes a probability as the input and produces a Z score as the output. The negative Z scores have been converted to positive probits by adding 5 to the Z score.

| Drugs Found | Overdose Deaths | Death Rate | Z Score | Probit |
|---|---|---|---|---|
| 1 | 1869 | 31.291% | -.488 | 4.512 |
| 2 | 1747 | 29.248% | -.546 | 4.454 |
| 3 | 1315 | 22.016% | -.772 | 4.228 |
| 4 | 639 | 10.698% | -1.243 | 3.757 |
| 5 | 267 | 4.470% | -1.699 | 3.301 |
| 6 | 106 | 1.775% | -2.103 | 2.897 |
| 7 | 23 | .385% | -2.665 | 2.335 |
| 8 | 6 | .100% | -3.089 | 1.911 |
| 9 | 1 | .017% | -3.587 | 1.413 |
| **Total** | **5973** | **100.0%** | | |

The probits were plotted and a linear trend line was added to the chart, along with the equation for the trend line, and the explained variance ($R^2$). Since the explained variance for a linear trend line based upon the probit plot is almost 98%, it would seem that the original plot is a probably a sigmoid plot.




These results should not be particularly surprising, since the methods of probits was developed to plot deaths by poisoning. The only difference between this application and the original application was that Bliss (1934; 1935) was working with microorganisms and small insects, and this plot demonstrates that human poisonings appear to follow the same pattern of dose response.

The probit plot seems to be linear, which would suggest that the original plot was a sigmoid plot, which suggests that the population of drug users has a normally distributed propensity for drug overdose. As the level of drug use increases, so does the chance of death by fatal overdose.

## *Curve Fitting in Python*

The next step would be to compare the fit of the original plot with alternative mathematical models. There are other types of mathematical models that could be examined, and the comparisons with the probit model do not seem to be part of the standard SPSS curve fit procedures. A generic curve fitting model was developed for Python in order to overcome this deficit. This program is shown below.

# Chapter 12: The Four Cases

In Chapter 5, it was determined that propensity is normal, sanctioning is asymmetric, and crime rates will follow a sigmoid normal response with changes in propensity or sanctioning. The goal in this chapter is to determine how this may be helpful. The ultimate goal would be to create some type of standardized scale where we could determine what portion of the crime rate was due to the propensity to harm and what portion of the crime rate is due to sanctioning.

The basic problem with the nonlinear relationship between propensity, sanctioning, and crime is that there are too many unknown variables. Consider that propensity and sanctioning are latent variables and cannot be observed directly. The only "real" data that criminologists have in abundance is crime rates. In Equation 16, there are two unknown variables, the sanctioning level (S) and the mean propensity to harm ($\mu_P$). Without some other evidence, this equation is impossible to solve because there are two unkowns.

In this chapter, an attempt will be made to resolve these difficulties. A path forward will be proposed. This effort will begin with a discussion of the ultimate goal and then a discussion of the methods required to achieve that goal.

## A Vision for the Future

The ultimate goal for criminologists would be to create a standard deviation scale that could be used to plot propensity and sanctioning. There are a few options available since a number of methods have been used to plot standard deviation scales. For example, microbiologists use the probit scale, and the individual difference researchers have developed the IQ scale. Each standard deviation scale has advantages and disadvantages.

The reason that developing a scale is important is because, if it were somehow possible to accurately assess propensity levels, it would be possible to create a propensity quotient, or PQ scale that was similar to the intelligence quotient or IQ scale. This would be very useful for comparing the crime rates of groups of people. In theory, a PQ scale is possible. One simply needs the right reference points.

However, as appealing as this concept sounds, finding the relative levels of propensity and sanctioning will be complicated. As de Candolle's (1830) and Durkheim (1895) noted, propensity and sanctioning are inextricably entwined. It is very difficult to determine whether variation in crime rates is due to variation in levels of propensity or variation in sanctioning levels. The only way to do this is to find situations where either propensity or sanctioning are zero and work from that. There is a case where propensity is zero, and this is in the age crime curve. Babies have essentially zero probability of committing a crime. This fact might be used to calibrate a propensity scale. However, one still needs to deal with the effects of sanctioning.

Before looking at that solution, there is a step that needs to be taken first. One must consider the mathematics of change and non-change. This discussion will be taken up in the next section.

## The Mathematics of Change and Non-Change

One way to get rid of variables is to look for situations where a variable could be considered to be a constant. In the present case, we want to find situations where either propensity or sanctioning is constant. If both variables are constant, or both variables change, we can't determine their respective contributions. We need to find special situations where only one variable changes and the other is constant.

In a two variable situation, there are four cases of constancy and variation to consider. The four cases are listed below. It would seem that we should be looking for cases #2 and #3, since they provide a chance to see how changes in either sanctioning or propensity affect the crime rate.

**The Four Cases**

| Case # | Propensity | Sanctioning | Crime Rate |
|---|---|---|---|
| 1 | Constant | Constant | Constant |
| 2 | Constant | Varies | Sigmoid |
| 3 | Varies | Constant | Sigmoid |
| 4 | Varies | Varies | Unknown |

## *The Effects of Change*

There is an interesting relationship between propensity and sanctioning. A unit unit change in either has the same effect on the crime rate. I have not been able to find any discussion in the literature about this, and the reasons that it is not discussed are not clear. It does not seem that this model has received much discussion. This model will be important for discussions of the four cases.

## *A Modified Standard Normal Distribution*

In order to work with the four cases, a modified standard normal distribution is required. The modified standard normal distribution still has a standard deviation of one, but the mean is no longer zero. The reasons for this modification will become clearer as we look more closely at the model.

Recall from Equation 10 that when the mean propensity is zero, the CDF for the normal distribution can be stated in terms of the propensity (P) of the sample. However, in reality, the mean propensity is not zero. The mean propensity is something other than zero. The mean propensity for crime is some small, but non-negative value. If we want to observe variation in the propensity for crime, we need to keep this one fact in in mind, the mean propensity for crime is not zero. The goal of criminologists will be to determine the actual value of the mean propensity for crime. The only way to do this is to find out how many standard deviations from zero the mean propensity level is at.

Let's revisit Equation 10, which is the CDF for a standard normal curve. The sanction level (S) is the lower bound of the propensity that provides the asymmetric threshold in the CDF. The propensity (P) is the mean sample propensity. For ease of modeling, it was assumed that the mean propensity was zero, but if the mean propensity was not zero, the mean propensity (μ) would need to work its way back into the equation as shown in Equation 17.

$$\Phi(P - \mu) = \frac{1}{\sqrt{2\pi}} \int_{S}^{\infty} e^{\frac{-(P-\mu)^2}{2}}\, dP \qquad \text{Equation 17}$$

These variables are all on the same scale. It is important to remember that this is a standard deviation scale where the standard deviation is set to one. Therefore, a one unit increase in sanctioning has the same effect on the crime rate as a one unit increase in the mean propensity of the sample.

Recall that only a few percent of the population is committing crimes. Therefore, the only way to find the mean is to observe variations in propensity and infer where the mean may be. This requires an edge centered model.

## ***The Effects of Non-Change***

There are some interesting issues that arise because of the mathematics of non-change. This is worth examining because constants in the model drop out of the equations and we must remember that they are there, whether we can measure them or not.

The first case of non-change is Case #1. This is the most non-changing of the four cases, there is no way to tell what fraction of the crime rate is caused by sanctioning and what fraction is caused by propensity. Crime is some constant feature of the environment that is caused by some unknown mixture of propensity and sanctioning. However, this should not mislead us into forgetting that propensity is normal and sanctioning is an asymmetric process. Crime rates may be constant at the population level, but they are not at the individual level.

Cases #2, #3, and #4, are a little more interesting. They become interesting because the only way to find any clue about the levels of propensity or sanctioning is to look at changes in the crime rates. In order to understand the intricacies of these three cases, it will be helpful to examine the effects of change and non-change in a two variable nonlinear system.

In the discussions that follow, the symbol for Delta (Δ) will be used as a shorthand for "change in." Therefore, "Change in X" can be read as Delta X, and symbolized as ΔX. Since the relationship between the crime rate and the quantile of the crime rate is nonlinear, the formula for the change in the quantile of the crime rate ($\Delta Z_S$) has to be the differences between the quantiles at the first and second measurements as shown in Equation 18. Propensity and sanctioning are on a linear sale and so their delta values can be calculated with Equation 19 and 20.

$$\Delta Z_S = \Phi^{-1}(Crime\ Rate_1) - \Phi^{-1}(Crime\ Rate_2) = Z_{S1} - Z_{S2} \qquad \text{Equation 18}$$

$$\Delta S = Sanctioning_1 - Sanctioning_2 \qquad \text{Equation 19}$$

$$\Delta \mu_P = Propensity_1 - Propensity_2 \qquad \text{Equation 20}$$

Sanctioning and propensity have a linear relationship with $Z_S$, so Equation 16 can be restated in terms of Delta variables from Equations 18, 19, and 20 and the result will be as shown in Equation 21.

$$\Delta Z_S = \Delta S - \Delta \mu_P \qquad \text{Equation 21}$$

If we observe the formulas for change, it will be helpful to next consider the effects of non-change. What happens as one of the variables is constant? Our change equation becomes a little simpler. When sanctioning or propensity are constant, they disappear from Equation 20. The mathematical relationships between $\Delta\mu_P, \Delta S,$ and $\Delta Z_S$ with one non-changing variable are shown below in Equations 22 and 23.

$$Case\ \#2: If\ Propensity_1 = Propensity_2, then\ \Delta\mu_P = 0, and\ \Delta Z_S = \Delta S \qquad \text{Equation 22}$$

$$Case\ \#3: If\ Sanctioning_1 = Sanctioning_2, then\ \Delta S = 0, and\ \Delta Z_S = -\Delta\mu_P \qquad \text{Equation 23}$$

After considering these relationships, it seems to be clear that it is extremely important to determine, from looking at the evidence, whether propensity or sanctioning is constant. If one or the other factor is constant, it will be possible to find something out about the other factor. The models for each case are presented below.

In each case, we are trying to learn something about constant factors that are not observable directly. We can only observe these latent constant variables by observing changes in dynamic variables. This process can be simplified if care is taken to think through the case being studied.

## The Four Cases: A Closer Look

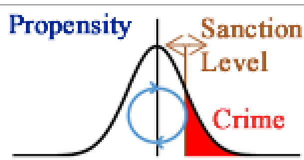
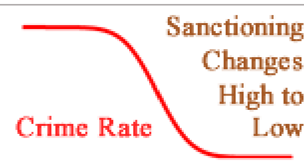
Each of the four cases has a different mathematical model. The differences between these models should be understood if they are to be used in practice. In particular, there are subtle differences between models that should be understood. The following sections provide a closer look at the differences between the four cases.

### *Case #1: Propensity and Sanctioning are Constant*

The problem with crime rates is that they rarely change. This was the problem noted by Quetelet (1833/1984). He describes a crime budget where the same numbers of murders, rapes, assaults, thefts, etc. occur each year. This is a probabilistic process and is interesting, but rather uninformative. Crime is some constant feature that we must live with.

### *Case #2: Propensity is Constant and Sanctioning Varies*

If propensity is constant, and sanctioning varies, calculating the relationship between changes in sanctioning and changes in the crime rate is relatively simple from a conceptual standpoint. This is a standard Z score model where the crime rate is calculated directly from the Z score. This model is shown graphically below.

<table>
<tr><td colspan="2">Case #2: Propensity is Constant and Sanctioning Varies</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td colspan="2">In Case #2 the propensity level is constant and sanctioning varies. From looking at the model on the left, if the mean propensity is constant, changes in the sanctioning level ($\Delta S$) would be equal to the changes in the Z score ($\Delta Z$). The model on the right shows how the crime rate would change with changes in sanction level. High crime values would be on the left and low values on the right.</td></tr>
</table>

This model seems to be similar to the standard normal model. In the standard normal model, the mean propensity is set to zero, and the sanction level is simply the value of the quantile of the crime rate ($Z_S$). This Equation is shown in Equation 24.

$$S_{\mu_P=0} = Z_S \qquad \text{Equation 24}$$

This model is similar in nature to one used by microbiologists for plotting germ kill rates for various levels of antiseptic strength. In these calculations, the resistance to antiseptics is constant between samples. Case #2 is a variation of the model proposed by Brooks (1918) to plot the CDF of a bell curve. This model is used extensively in medical applications to plot dose response curves. If sanctioning moves from +5 to -5 standard deviations, the crime rate will move from 0 to 100%.

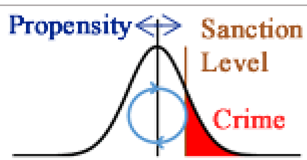
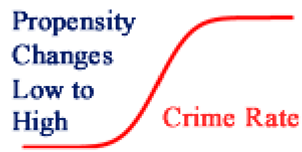
A problem that has been noted with this model is that it produces negative values. The quantile value ($Z_S$) varies from +5 to -5. In general, we do not like thinking about negative sanctioning. It would be nice to consider a positive scale for sanctioning.

Microbiologists got around this problem by creating the probit scale for plotting germ kill rates in terms of antiseptic strength (Bliss, 1934; 1935). The probit is calculated by using the quantile function with the germ kill rate to create a Z score, and adding 5 to create a "probit" or probability unit. A probit scale is a standard normal standard deviation scale where the mean is five (instead of zero) and the standard deviation is one. A careful consideration of the similarities between the antiseptic model and the crime rate model suggests that the antiseptic model is similar to Case #2 of the four possible variation cases. In the antiseptic model, germ resistance is constant while antiseptic strength varies.

The probit scale is a usable scale, but one must be careful to insure that propensity is constant as in Case #2. Where propensity is changing, sanctioning is either constant (Case #3) or variable (Case #4). The next step is to consider Case #3.

## *Case 3: Propensity Varies and Sanctioning is Constant*

When propensity varies and sanctioning is constant, the calculations become a little more complicated than in Case #2. The reasons become a little more apparent from looking closely at the model below. The Z score seems to be a measure of sanctioning, as was proposed in Case #2, but in Case #3, the Z score is actually an offset measure of propensity. This situation needs to be examined closely.

| **Case #3: Sanctioning is Constant and Propensity Varies** | |
|---|---|
|  |  |
| In Case #3 the propensity level varies and sanctioning is constant. From looking at the model on the left, if the mean propensity ($\mu_P$) is not equal to the Z score at a particular sanctioning level ($Z_S$). The mean propensity is equal to the Z score minus a constant (C). | |

In order to try to make sense of this, return again to Equation 15. If the standard deviation of the propensity distribution can be considered to be one unit, the sanctioning level (S) is equal to the mean propensity ($\mu_P$) plus the quantile of the crime rate at a particular sanctioning level ($Z_S$). Assuming that the sanctioning level (S) is a constant ($C_S$), then the formula for the mean propensity is shown in Equation 25, and the constant value can be calculated using the formula in Equation 26.

$$\mu_P = Z_S - C \qquad \text{Equation 25}$$

$$C_S = Z_S - \mu_P \qquad \text{Equation 26}$$

The value of the constant is difficult to determine without a reference point.

For instance, using the model below, assuming a probit scale of 0-10, if the mean propensity ($\mu_P$) would be equal to 5. Assuming a sanctioning level ($Z_S$) of 7, using Equation 19, the sanctioning constant value would be 2 ($C_S = 7 - 5$), and the equality in Equation 18 would be satisfied ($5 = 7 - 2$).

### Plotting the Trajectory of the "Average Man"

One of the interesting features of Case #3 is the ability to plot the trajectory of the "Average Man." The concept of the average man was developed by Quetelet (1833/1984). He envisioned a science that involved the study of the average, or mean qualities of humans. Very little has been done with this concept, but it appears that the properties of shifting normal distributions in the presence of fixed asymmetric selection processes provide a method for determining the trajectory of the average person.

## A Real World Example: Crime Rates in the US for Various Groups

The goal of these exercises has been to find some way to relate changes in crime rates to changes in propensity. Since Quetelet's (1833/1984) assumption of a linear relationship was not valid, there was a need to find a way to work with the nonlinear relationship between propensity and crime rates.

The microbiologists developed the probit scale (Bliss, 1934; 1935), which is a positive scale from 0-10 standard normal deviations (Z scores). Another Z score transformation method has been used by human individual difference researchers. This method is called the Intelligence Quotient, or "IQ" scale. The IQ scale is used to plot differences in intelligence in terms of standard deviations. The IQ scale is a standard normal deviation scale where the mean is set to 100 and the standard deviation is set to 15 points. The IQ scale has the advantage of a large user base and the possibility that one might conceptualize the propensity to harm as being similar in nature to a propensity to do something intelligent.

If, as suggested, the propensity to harm is normally distributed, it would be helpful if there was scale that could be used to calculate either a Propensity Probit (PP) or Propensity Quotient (PQ) scale. This would give criminologists a way to compare groups of people and make more informed decisions about the sanctioning process. The problem is that propensity and sanctioning are tied together. This might not seem to be such a big problem at first, but the relationship between propensity, sanctioning, and crime rates is highly nonlinear. To see why this might be a problem, it will be helpful to look at some real data.

## The Sanction Probit ($SP_{US}$) or Propensity Quotient ($PQ_{US}$) Scales for the US

If one assumes constant sanctioning within a region, it is possible to create a sanction probit (SP) or propensity quotient (PQ) scale for that region. For example, one could assume constant sanctioning for anyone living in the US. Then the SP or PQ scale for the US ($SP_{US}$ or $PQ_{US}$) could be estimated for various groups in terms of the mean US crime rate. We can look at how this might work for three US groups, males, females, and people released from prison.

Since we are interested in looking at how propensity levels vary from the mean, we need a variable to measure that variation. This variable will be called Delta $Z_S$ ($\Delta Z_S$). The value of $\Delta Z_S$ can be determined by subtracting the quantile of the crime rate for the mean population, symbolized as $Z_{S_{\mu_P}}$, from the quantile of the crime rate for the group, symbolized as $Z_{S_X}$.

$$Delta\ Z_S = \Delta Z_S = Z_{S_X} - Z_{S_{\mu_P}} \quad \text{Equation 27}$$

Calculating the value of Delta Z makes it easier to visualize the effects of changes in Z score. It can also be used to calculate the values of the sanction probit (SP) or propensity quotient (PQ). Take the values for the US from 2014 as an example. The crime rates for three groups were calculated from UCR and prisoner release data. The prisoner release crime rates were obtained from looking at a graph, so they are general estimates.

| Group | 2014 Crimes | UCR Base Population | Crime Rate | Observed Z Score | Delta Z | Sanction Probit (SP) | Propensity Quotient (PQ) |
|---|---|---|---|---|---|---|---|
| US Total | 8,224,259 | 232,219,578 | 3.5% | -1.81 | | 3.19 | 100.0 |
| Males | 6,021,910 | 116,109,789 | 5.2% | -1.63 | .18 | 3.37 | 102.7 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Females | 2,202,349 | 116,109,789 | 1.9% | -2.08 | -.27 | 2.92 | 96.0 |
| Ex-Prisoners | | | 42.0% | -.20 | 1.60 | 4.80 | 124.1 |

The UCR crime rates for the US for 2014 indicated that there were just over 8 million arrests out of a base reporting population of 232 million. Since we do not know the exact percentages of this sample population that were male or female, a 50% split will be used for estimation purposes. This means that the crime rate for males was about 5% and the crime rate for females was about 2%. This is a ratio of about 2.5 male crimes for every female crime. As mentioned in the conundrums, it does not seem likely that males have 250% more of something than females, and so the differences in crime rates do not seem related to differences in propensity.

If we calculate the quantiles of these crime rates however, the magnitudes of the differences in propensity between males and females become clearer. The quantile of the crime rate for the entire US population is -1.81, which was converted to a sanction probit ($SP_{US}$) of 3.19 by adding 5 to the quantile. The method for calculating the sanction probit for the other groups is the same ($SP = Z_S + 5$).

The quantile of the male crime rate is .18 standard deviations higher than the US average, and the quantile of the female crime rate is .27 standard deviations lower. This suggests that the difference in the propensity to harm others between males and females is only .45 standard deviations. Since the total effective range of variation is ten standard deviations, this finding suggests that males commit more crimes because their propensity to harm others is 4.5% higher than the propensity for females.

The propensity quotient for the average citizen ($PQ_{US}$) was set to 100 by first multiplying -1.81 by 15. This produced a value of -27.1 for the US mean crime rate. A value of 127.1 must be added to -27.1 in order to set the mean population PQ to 100. In order to calculate the other PQs, the quantile of the crime rate was multiplied by 15 and 127.1 was added to the result.

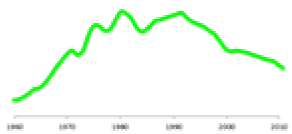
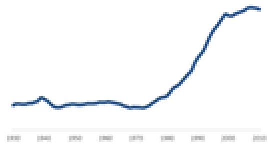
In terms of PQ score, males have a PQ of 102.7 and this is 6.7 points higher than the female PQ score of 96. The small difference in average PQ score between males and females seems to make more sense than assuming a 250% difference in propensity.

Note that prisoners released from prison in the US have a one year arrest rate of about 42%. The quantile of the crime rate for this group is about 1.6 units higher than the US mean. This suggests that prisoners released to the community have a 16% higher propensity for crime than the average US citizen. Their PQ score is 124.1.

### *Case 4: Propensity and Sanctioning Both Vary*

If both propensity and sanctioning both vary, it is not clear what might happen to the crime rate. A recent example of this occurred on the U.S. in the past decade. The propensity for crime has been going down since the mid-1990s. However, the sanctioning level has been going up. It is very difficult to determine the values of the mean propensity when this situation occurs.

| |
|---|
| Crime rates peaked in the mid-1990s |

| | |
|---|---|
|  | Crime rates peaked in the mid-1990s. All measures of the propensity for harming others suggest that people are less likely to harm each other today than they were in 1995. |
| Sanctioning levels have climbed since the 1970s | |
|  | The level of sanctioning increased in the 1970s and has continued to climb, even though the propensity for crime is declining. This provides a challenge, because there are too many variables. Some other information is needed to determine the relative contributions of propensity and sanctioning to the crime rate. |

# Chapter 13: Working with Dynamic Phenomena

Criminal propensity has complex dynamics (See chapter 7). These dynamics are caused by fluctuation in many hundreds of variables. Finding order in this chaos is a challenging feat. It may be that there is no way to really make complete sense of this chaos. However, there are a number of methods that are being tried.

The basic premise of the following discussion is that people are always changing. We are not the same person from moment to moment, from hour to hour, from day to day, from year to year, etc. However, we are similar to the person we were a little while ago. There is a need to study the similarity between the individual in this moment vs. the individual from a moment ago in the face of constant change.

The term most commonly used for fluctuation within the person is "intra-individual variation." This is separate from inter-individual variation, which is variation between individuals. It would seem safe to say that there has been very little analysis of intra-individual variation in criminal propensity.

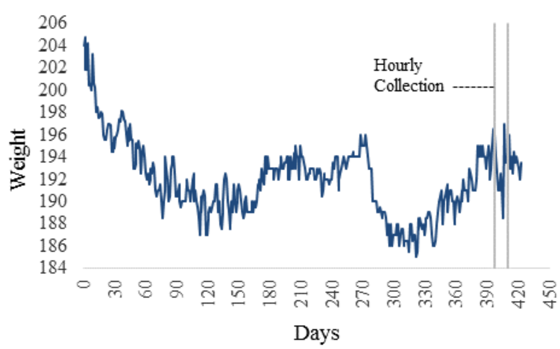
## A Brief Example

Before continuing, it may help to provide a brief example. This example involves intra-individual variation in weight, which may seem unrelated. However, intra-individual variation appears to be similar in nature across many different human characteristics, and so it may be possible to study intra-individual variation in weight in order to get an idea about how intra-individual variation in criminal propensity occurs.

In order to study fluctuation, one must first collect longitudinal data in a time series. Then, one must try to analyze this time series data. The problem with this type of time series data is that it does not seem to follow any sort of consistent pattern. It is difficult to predict with any degree of accuracy where the next data point will occur.

To illustrate the problems with trying to assess time series data, I needed a time series data set. This was not particularly hard to create, although it took some time. I weighed myself daily over the space of a year. I did this the first thing in the morning and entered the value in an Excel spreadsheet. I was trying to lose weight and had some success at first. As you can see, there is fluctuation between days and also over weeks, months, and the year or so that I have been making these measurements.

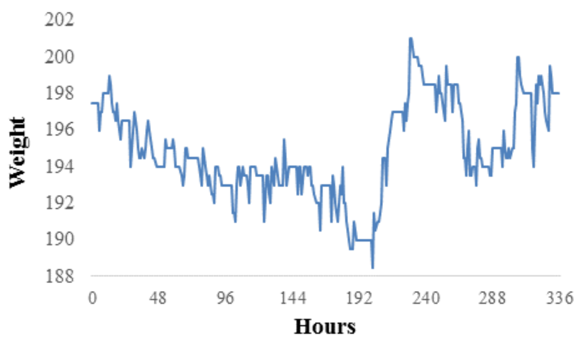
**Daily Weight Chart**




If there is anything that can be predicted from this chart, it would seem that I could predict that if my weight goes down, it will go up again. If my weight goes up, it will go down again. The "rule" seems to be that fluctuation occurs. This fluctuation seems to occur within bounds. That is, my weight never gets above or below certain limits.

For the next step, I wanted to see how my weight was changing hourly. I used the same procedure as above, but took hourly weight measurements for 14 days. The days are from 397 to 410 on the daily weight chart. The collection process turned out to be easier than expected because I found that my weight did not change much while I was sleeping. Therefore, I was able to get a fairly complete 24 hour per day chart. Note that the hourly chart looks similar to the daily chart. There is fluctuation by hour and by day. Declines are followed by increases and increases are followed by declines. In one day, I gained 10 pounds while on a road trip attending a family feast. This was after a week of dieting. There would seem to be a fair amount of daily fluctuation.

**Hourly Weight Chart**




## Methods for Dealing with Fluctuation

The preceding example provides a brief overview of the problems with measuring properties that fluctuate. This can be difficult ate best. It will be helpful to review some of the methods that are being used to deal with intra-individual variation.

### *Error*

Probably the most common method of dealing with fluctuation is to call it "error." The reason for this comes from a notion that human characteristics are relatively stable. In the study of psychometric measurements, fluctuation is thought of as an error that can be ignored. This reasoning is the basis behind the true score model popularized by Lord and Novak (1986).

The logic behind the true score model is that a measurement is subject to some level of error. Therefore, a measurement (X) can be thought of as the sum of the "True" score (T) and an error term (e).

$$X = T + e \qquad \text{Equation 24}$$

In theory, with repeated measurements, the error terms are random and will be normally distributed. This means that after a large number of measurements, the error terms should add up to zero.

$$\sum e = 0 \qquad \text{Equation 25}$$

Therefore, the True score should be equal to the average of many measurements.

$$T = \sum X/N \qquad \text{Equation 26}$$

The problem with the true score model is that any intra-individual variation is thrown out. If intra-individual variation is occurring, it is considered to be "error" and ignored. This does not provide a method for studying intra-individual variation.

### *Standard Error*

The concept of standard error provides a little more information.

## Intra-Individual Variation

It will be suggested that the technical term for fluctuation in human characteristics is intra-individual variation. In an age when people routinely turn to Google searches, this term will bring up a variety of discussions related to this topic. If criminologists would switch to using the term intra-individual variation, it would bring the discussion into the broader scientific community.

## There is No True Score

Inherent in the discussions of intra-individual variability is the premise that if intra-individual variation is occurring, there is no true score. Within the limits of error, the score at time 2 ($X_2$) is equal to the score at time 1 ($X_1$) plus the change in score (delta X) from time 1 to 2 ($\Delta X_{1\text{-}2}$), plus the original error at time 1 ($e_1$), plus the change in measurement error from time 1 to time 2 ($e_{1\text{-}2}$).

$$X_2 = X_1 + \Delta X_{1\text{-}2} + e_1 + \Delta e_{1\text{-}2} \qquad \text{Equation 27}$$

If the errors are small in magnitude compared to the measures ($X_n$) and any intra-individual variation that is occurring ($\Delta X_{n\text{-}m}$), then the errors can be temporarily ignored and the following relationship holds. The score at time 2 ($X_2$) is approximately equal to the score at time 1 ($X_1$) plus the approximate change in score (delta X) from time 1 to 2 ($\Delta X_{1\text{-}2}$),

$$X_2 \approx X_1 + \Delta X_{1\text{-}2} \qquad \text{Equation 28}$$

. The True score at a particular point in time (t) is the sum of the average X and the change in X from time t1 to time t2, symbolized by the term delta X ($\Delta X$).

$$T(t) = \sum X/N + \Delta X$$

Equation 27

The

phenomenon is very interesting and can be studied by looking at intra-individual variation in factors

# Section 4: Practice

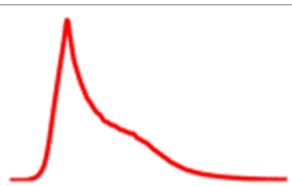
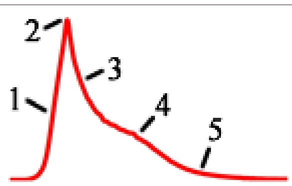
# Chapter 14: The Age Crime Curve

The purpose of this chapter is to present a solution to the age crime curve. The solution requires a multilevel process of curve fitting with three separate nonlinear processes. The net result is an almost perfect set of formulas that explain the age crime curve from birth to death.

This solution may seem complex, but the assumptions made are realistic, and the formulas have such a close fit to reality that it becomes apparent that nature has very precise rules that it operates under. This seems to be particularly true at the population level.

In order to understand the difficulty of the problems involved, it is helpful to examine the age crime curve shown below. The following plot was obtained from data collected by the Federal Bureau of Investigation (FBI) through the National Incident Based Reporting System (NIBRS). The data collected spanned the years from 1996 to 2006. This aggregation level produced a very smooth curve that represents the crimes of several thousand individuals over several years.

The important thing to note is that there are actually five distinct features of the age crime curve that must be explained. The crime rate rises quickly from 0-18. Then, there is a sharp reversal in the age crime trajectory at about age 18 for males and age 16 for females. There is a milder decent that flattens out at about age 35. The crime rate actually increases briefly from age 35 to 40. Finally, the crime rate follows a gentle declining curve from about 40 to 99.

| **The Age Crime Curve** | |
|---|---|
|  | The distinctive curve in the crime rate by age is called the “age crime curve” (Farrington, 1986). The peak age of crime in the U.S. age crime curve shown on the left is at about age 18. |
| **The Five Features of the Age Crime Curve** | |
|  | The age crime curve has five distinct features.<br>1. In the period from ages 0-18 there is a sharply rising curve.<br>2. At about age 18 (16 for females) there is a sharp reversal.<br>3. There is a curved descent from ages 18-30.<br>4. Crime picks back up slightly from ages 35-40<br>5. There is a gradual curved decline from about age 40 onward. |

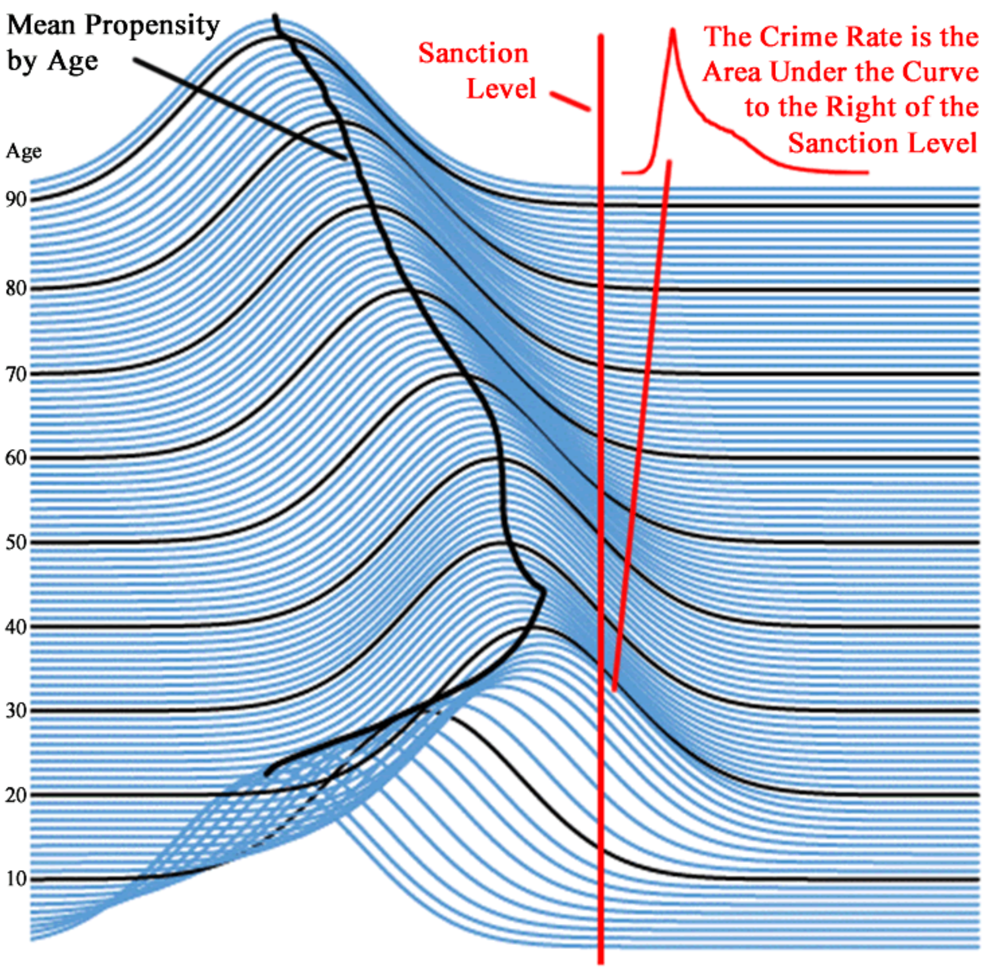
It is possible to build a mathematical model that explains all five of these features. The model has some very interesting features. Because it is a nonlinear model, the model is highly sensitive to initial conditions. That is, a very small change in the parameters used result in a model that does not work. The precise nature of the model suggests that one can use the age crime curve to determine the precise biological changes that cause the age crime curve. This suggests that this process could help researchers find exactly which developmental changes are most important for criminologists to understand.

## The Importance of Case #3

Four cases were presented in Chapter 9. One of the best illustrations of Case #3 is the age crime curve. Recall that in Case #3, propensity is varying while sanctioning is constant. In the age crime curve, the mean propensity for crime is varying by age within a population. Assuming that the sanctioning level is not varying by age, sanctioning (S) can be assumed to be constant. If sanctioning is constant, and propensity is varying, the age crime curve provides an ideal opportunity to test the Case #3 scenario.

The basic premise behind this model is that people at each age can be thought of as a group. Because criminal propensity is massively multivariate, complex, and normal (MMCaN), the criminal propensity at each age should be normally distributed. Because the age groups are approximately equal in size, it is reasonable to assume that the standard deviations of the propensity distributions are approximately equal. This means that a standard normal distribution with a shifting mean can be used to model the age groups. The quantile function can them be used to plot the age propensity curve, which is shown below.

***Plotting the Age Propensity Curve Using Normal Distributions for Ages 2-92***




Getting to this model took some work. In hindsight, the approach makes perfect sense, but this was not immediately apparent, and the solution requires several steps. It will help to look at some of the research that was present before this model was developed.

## Some History

Criminologists have been trying to find a solution to the age crime conundrum for 180 years. The work in this area began in earnest with Quetelet's (1833/1984) work on the propensity for crime at different ages. There was some intervening work in this area, but interest in the age distribution of crime did not begin to heat up until Hirschi and Gottfredson (1983) reviewed this topic and noted that the age distribution of crime "easily qualifies as the most difficult fact in the field" (p. 552). The term "age crime curve" was coined by Farrington (1986), and this term has been used extensively ever since.

In this chapter, a mathematical solution to the age crime curve will be presented. The idea that criminologists should search for the mathematical form of the age crime curve was suggested by Britt (1992). The efforts that follow flow from that suggestion.

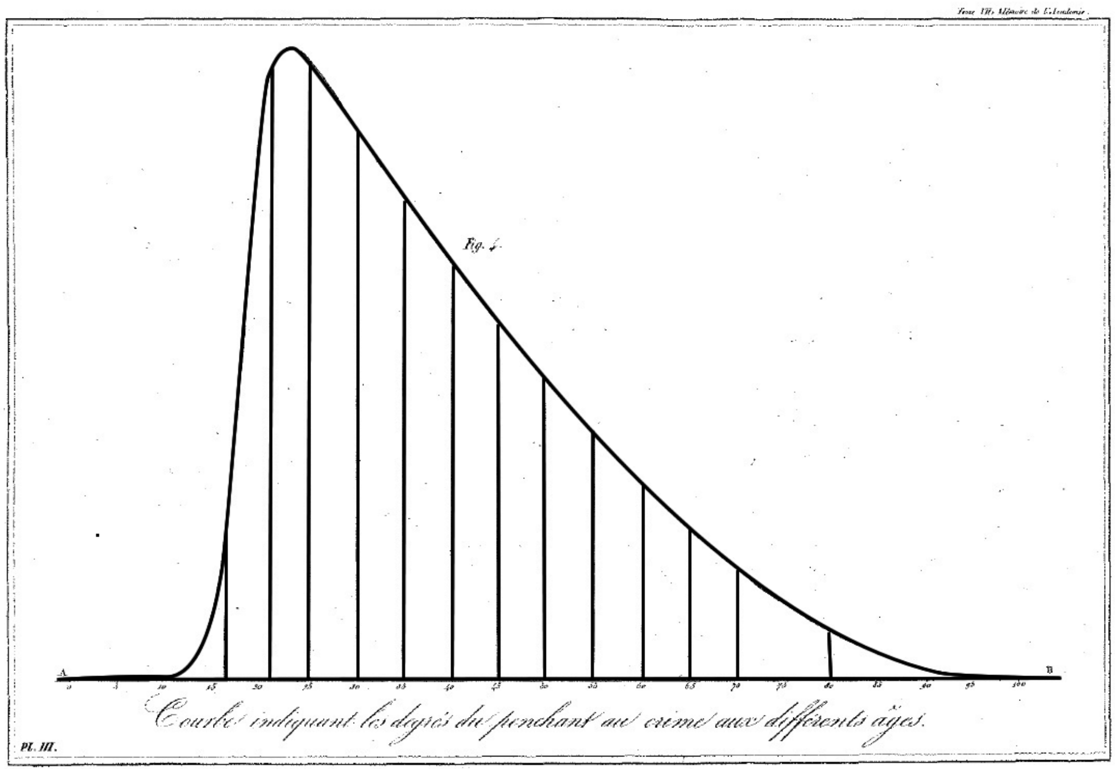
### *Quetelet's Developmental Lag Theory*

France began collecting crime rate data in 1825. Quetelet (1831; 1833/1984) analyzed this data and noted that crime rates seem to vary quite markedly by age, gender, reading ability, area of the country and time of year. Quetelet (833/1984) began his work by proposing a new way of looking at the problem of crime. He suggested that we study the "average man" and that it was possible to build a social mechanics that was similar to a celestial mechanics. He went on to suggest that the age crime curve was caused by a developmental lag between strength, passion, and reason. In later work, he suggested that the propensity for crime followed the law of accidental causes, which we would consider to be the normal distribution. His work seems to be predicting the model that will be presented later in the chapter. It would seem to be worthwhile to explore his ideas.

### *Building the Developmental Lag Theory*

In his exploration of crime rates by age, Quetelet (1833/1984) found that crime rates begin to rise sharply in childhood and rise to a sharp peak in late adolescence and young adulthood. At that point the crime rates drop almost as quickly as they rose, until few people commit crimes in old age. His plot of the age crime curve is shown below.

**Quetelet's Plot of the Age Crime Curve**




Quetelet (1833/1984) argued that the age crime curve was caused by a developmental lag between strength, passion, and reason. His arguments seem to have been buried, since I cannot find them cited anywhere. He seemed to be convinced that he had found the reason for the age crime curve. Strength and passion developed before reason, and this was why crime varied by age. Quetelet's (1833/1984; pp54-55) comments are reproduced below.

> **CONCERNING THE INFLUENCE OF AGE ON THE PROPENSITY FOR CRIME**
>
> Among all the causes which have an influence for developing or halting the propensity for crime, the most vigorous is, without contradiction, age. It is, in fact, with age that man's physical strength and passions develop and that their energy afterwards diminishes. It is also with age that reason develops which still continues to grow when strength and passions have already exceeded their maximum intensity. In considering only these three elements, strength, passion, and reason in man, it could be said almost a priori what must be the degrees of the propensity for crime at different ages. This propensity must be practically nil at both extremes of life since, on the one hand, strength and passions, those two powerful instruments of crime, have scarcely been born, and when, on the other hand, their energy (pretty nearly extinguished) is found weakened by the influence of reason. The propensity for crime, on the contrary, must be at its *maximum* at the age where the strength and passions have attained their *maximum*, and where reason has not acquired sufficient command to dominate their combined influence. In considering, then, only physical causes, the propensity for crime at different ages would depend especially on the three qualities of which we have just spoken, and would be determined by them if they were sufficiently understood.

## *Quetelet's Mathematical Model*

Quetelet (1833/1984) went on to try to find the mathematical form of the age crime curve. He suggested that crime by age could be represented by a sinusoidal function expressed Equation 29 (p. 57). He later simplified this to Equation 30 (p. 58).

$$Y = (1 - \sin X)\ \frac{1}{1+m}, supposing\ m = \ \frac{1}{2^{X} - 18} \qquad \text{Equation 29}$$

$$Y = (1 - \sin X) \qquad \text{Equation 30}$$

## *Fitting Data*

Quetelet (1833/1984; pp. 62-63) went on to compile data on the level of strength and mental capacities by age. He compiled data from a number of sources, and placed them in a table as follows.

**Quetelet's Table 17**

| AGES | STRENGTH OF | | AT CHARENTON | | RELATIONSHIP | LUNATICS taking account of population | MASTERPIECES of the French stage | |
|---|---|---|---|---|---|---|---|---|
| | hands | backs | admissions | cures | | | | |
| 10 | 25 | 4 | - | - | - | - | - | - |
| 15 | 60 | 9 | 22 | 11 | 2 | 21 | - | - |
| 20 | 82 | 14 | 67 | 30 | 2,2 | 79 | 3 | 3 |
| 25 | 85 | 14.5 | 86 | 40 | 2,2 | 109 | 12 | 12 |
| 30 | 88 | 15 | 98 | 36 | 2,7 | 134 | 26 | 26 |
| 35 | 90 | 15.5 | 81 | 25 | 3,3 | 125 | 27 | 28 |
| 40 | 88 | 15 | 79 | 21 | 3,8 | 129 | 26 | 28 |
| 45 | 75 | 14.5 | 72 | 14 | 5,1 | 131 | 30 | 34 |
| 50 | 70 | 14 | 52 | 12 | 4,3 | 108 | 21 | 29 |
| 55 | 65 | 13.5 | 21 | 6 | 3,5 | 51 | 7 | 11 |
| 60 | 60 | 13 | 21 | 9 | 2,3 | 63 | 5 | 10 |
| 65 | 55 | 12 | 6 | 1 | 6 | 24 | 6 | 14 |
| 70 and more | | | 14 | 4 | 3,5 | 45 | 3 | 10 |

Quetelet (1833/1984) concludes on Page 64.

> Thus, it would be between the ages of 45 and 50, all things being equal, that most of the dramatic masterpieces would have been produced in France. It is then that imagination and reason produce the most; and, by a singular contrast, it is around this age also that mental alienation has the most influence and causes maladies whose cure offers the most obstacles. The intellectual life of man and the maladies of his mind develop especially around 25 years, an age where animal development has almost ceased. Man, in fact, at that age, is nearly entirely developed as to height, weight and physical strength; and it is at this extremity that the maximum of the propensity for crime appears. It is again notable by another comparison that it is between the ages of 25 and 30 that the limit of the average life falls. Thus the average man between the ages of 25 and 30 has ended his physical development, and it is also at this age that his intellectual life develops with the most energy. I believe that these relationships will furnish a new example of utility whose general effect would be laws relative to the principal qualities of man.

## *Later Work on Normal Distributions*

Quetelet (1848; 1869) went on to suggest that the propensity for crime follows the "law of accidental errors." In modern terms, we would interpret his statements as suggesting that the propensity for crime is normally distributed. Quetelet's (1848) work does not seem to have been translated into English. I do not speak French, but was able to use Google Translate to come up with the following translation of Quetelet's (1848; pp. 90-97) comments on age, crime, and normal distributions. This model is essentially the one presented in this book. He is envisioning between and within individual variation in criminal propensity that follows the "law of accidental errors." That is, propensity is normally distributed.

## *Slightly Off the Mark*

It should be noted that although Quetelet was headed in the right general direction, there is a problem with his model. In discussing how crime was created, Quetelet (1848) assumed that the propensity for crime at various levels was indicated by the height of the curve at each level. This, in itself was partly accurate, because he was working with a probability density function. However, he proposed that the probability of crime was the distance from the leftmost point to the line indicating the level of sanctioning. This is inaccurate because he should have been looking at the cumulative probability, which is the area under the curve.

The assumption of a linear relationship between the distance on the X axis and the crime rate is not mathematically correct, since the probability of crime is probably not a linear distance, it is the cumulative area under the curve to the left of the line. It seems that Quetelet (1848) was assuming a linear response in the probability of crime with changes in sanctioning. In the model presented later in the chapter, it will be demonstrated that the crime rate would actually be a nonlinear CDF with changes in crime being related to the area under the curve as the sanctioning level changes.

## *Is Quetelet's Work a Missing Puzzle Piece?*

In conclusion, Quetelet's work seems to be analogous to pieces buried in the pile of puzzle pieces. Quetelet (1833/1984) had begun work on developmental lag theory to explain the distribution of crime by age. He had suggested some mathematical formulas to explain how crime varied by age. He had begun looking at the "average" strength and mental capacities, and their fit with his theoretical model. Quetelet (1848; 1869) went on to suggest that the propensity for crime was normally distributed. Based upon the apparent lack of citations to the works mentioned above, his work in this area appears to have been almost completely ignored in the criminological literature. The reasons for this are not clear. The work is written in French and not translated. Perhaps language was a barrier. Even with translation, he is using outdated terms that people do not use today and one has to read closely to understand what he is saying. Another possible reason that Quetelet's work was ignored is that his ideas are foreign to how we think of science. There are many other possible reasons that this work could have been ignored. It is suggested that we might want to dig these pieces of the criminological puzzle work out of the dust bin.

Three Provocative Hypothesis

Much of the work on the age crime curve in recent years has been guided by an article written by Hirschi and Gottfredson (1983) on the age crime curve (cf. Sweeten, Piquero, & Steinberg, 2013). In Hirschi and Gottfredson's (1983) article, they proposed three provocative hypotheses.

1. Invariance - The age crime curve is invariant across time and group
2. Non-interactive - The factors causing the age crime curve do not interact with common criminological variables
3. Inexplicability - The age crime curve is driven by factors not normally used as crime correlates by criminologists

The following analyses provide considerable support for these three hypotheses.

# A Developmental Lag Model of the Age Crime Curve

The following developmental lag model for the age crime curve was developed after going through many iterations of testing and rejecting. There were a number of notable findings along the way. There were some vague ideas floating around in the back of my head to justify the models as I worked on these.

However, it was not until I had found a close fit to the entire model that I began looking for literature to support my theories. Before going on to the justifications for these theories, it will be helpful to summarize the various parts of the solution in the order in which they were found.

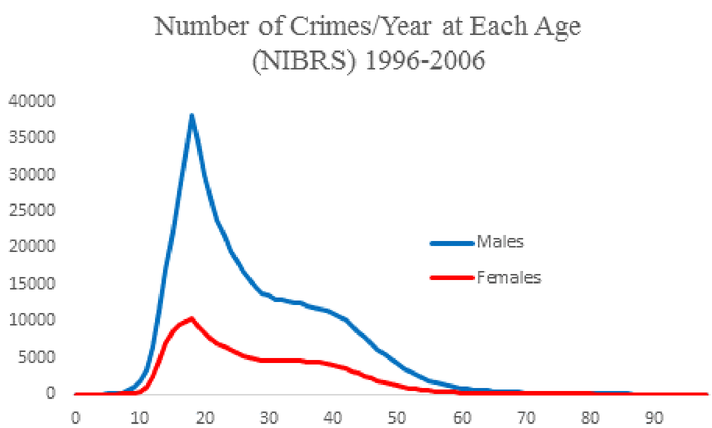
## *Invariance*

Hirshi and Gottfredson (1983) had proposed that the age crime curve is invariant across time and group. There has been an ongoing discussion about what exactly is invariant. Several articles (citations needed) have found that the age crime curve is not invariant across crime type. This can be demonstrated fairly easily by using the NIBRS age crime curve data.

### Males and Females have Similar Age Crime Curves

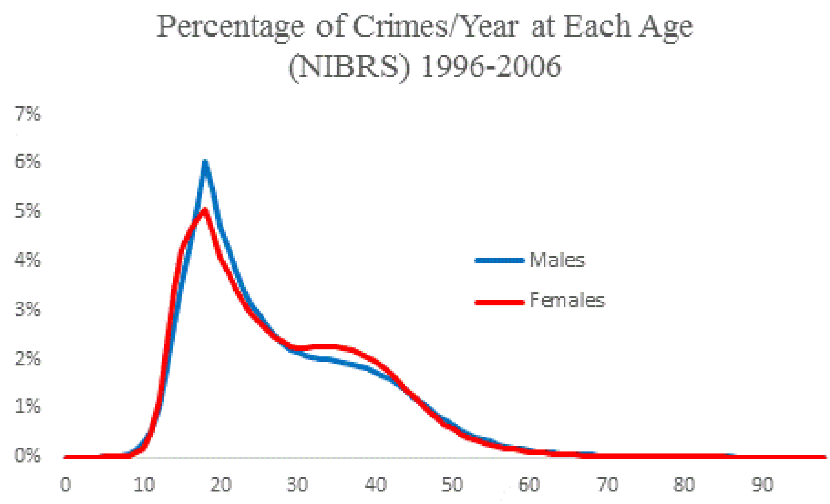
One of the first findings was that even though males and females have different levels of crime, the relative probability of crime at each age for males and females is almost identical. This may seem counter intuitive because the numbers of crimes committed at each age are quite different. Females commit about one fourth the numbers of crimes that males commit. See below.

**Numbers of Crimes per Year by Age and Gender in US (NIBRS - 1996-2006)**




However, when the probabilities of crime by age are “normalized” for males and females, by dividing the total numbers of crimes for each gender at each age by the total number of crimes committed over the entire life course by gender, the female age crime curve explains 97.6% of the variation in the male age crime curve. In essence males and females have essentially the same age crime curve, but the overall offending frequency at each age is proportionally less for females than it is for males.

**Percentage of Crimes per Year by Age and Gender in US (NIBRS - 1996-2006)**




## *A Sigmoid Relationship between Propensity and Crime Rates by Age*

The second finding was that the 1st and 5th sections of the age crime curve are almost perfect sigmoid curves. A sigmoid model was found that explains 99.995% of the variance in these two age ranges. It would appear that the age crime curve seems to be the result of shifts in normal propensity distributions by age that are transformed to a sigmoid distribution because of the sigmoid relationship between propensity, sanctioning, and the crime rate.

Recall that the age crime curve has 5 distinctive features. The first and fifth features of the age crime curve are sigmoid growth and decline curves. The suggested reason for this is that, in general, human development approximates a straight line increase from birth to about age 18, and a straight line decrease from ages 40 to 85. The best fitting model for the age crime curve from 0-18 and 40-80 is in the form of Equation 28.

$$Crime\ Rate_{Age} = p_{(Age)} = \frac{1}{C}\Phi\left(Z_{(Age)}\right) \qquad \text{Equation 28}$$

Where $p_{(Age)}$ = Probability of crime at a particular age

C = Constant

Φ = Standard Normal Cumulative Distribution Function

$Z_{(Age)}$ = The Propensity for Crime at Each Age = $mX + b$

X = Age in Years

m = Slope

b = Intercept

In the model above, note that the propensity for crime at each age ($Z_{Age}$) can be thought of a simple linear slope intercept model using Age as the X value. Although the explained variation provided by coefficient of determination ($R^2$) is not recommended for use with nonlinear models, it has a certain level of understandability and will be provided. The $R^2$ for Equation 21 suggests that over 99.995% for the age crime curve for both males and females in the age ranges 0-18 and 40-80 can be explained by the mean value of a normal propensity distribution increasing or decreasing by a set linear amount each year.

The reason why the constant C is needed is not entirely clear. The model suggests that the constant is needed because the crime rate is undervalued. This could be due to under reporting of the crime rate. The constant appears to be specific to each sample. One interesting thing about C is that the models suggest that the value of C that maximizes the explained variation for each gender in the age range 0-18, also maximizes the explained variation for that gender in the age range from 40-85.

## Try It Yourself

### *Try the Base Model in Excel*

A sample of the base model Excel spreadsheet used to make these calculations is available online. See the page at http://www.thecriminologicalpuzzle.com/try-it-yourself/ The spreadsheet has the male and female sample statistics along with a test back to fit normal curves. The age crime curves were obtained by calculating the variation in the probability of crime by age. That is, the percentages at each age represent the fraction of the total crimes that are committed by males or females at each age. (i.e. number of male crimes at age 18 / total number of male crimes).

Note that the section from 19-45 was fit by matching the values, and this means that the R Squared values are artificially inflated. The straight line Z-score model from equation 28.was used to match the model with the actual age crime curve sections from 0-18 and 46-98. The same constant was used in both the 0-18 and 46-98 year old model sections.

The method of fitting the model involved a fairly laborious task of changing each value in small increments until the lowest R Squared value and best visual fit was obtained. This is a rather unscientific method, since it is difficult to replicate. However, the results would seem to prove a point. The age crime curve from 0-18 and 46-98 is a set of sigmoid curves.

The actual values from the spreadsheet are shown below. Some caution should be used in interpreting the values. This is simply a proof of concept model, and the actual values for more precise data should be estimated. Again, note that the 19-45 values are calculated by manually fitting the values at each age. This results in extremely high R Squared values. The proof of concept values are the 0-18 and 46-98 values.

**Male Age Crime Curve Model Fit**

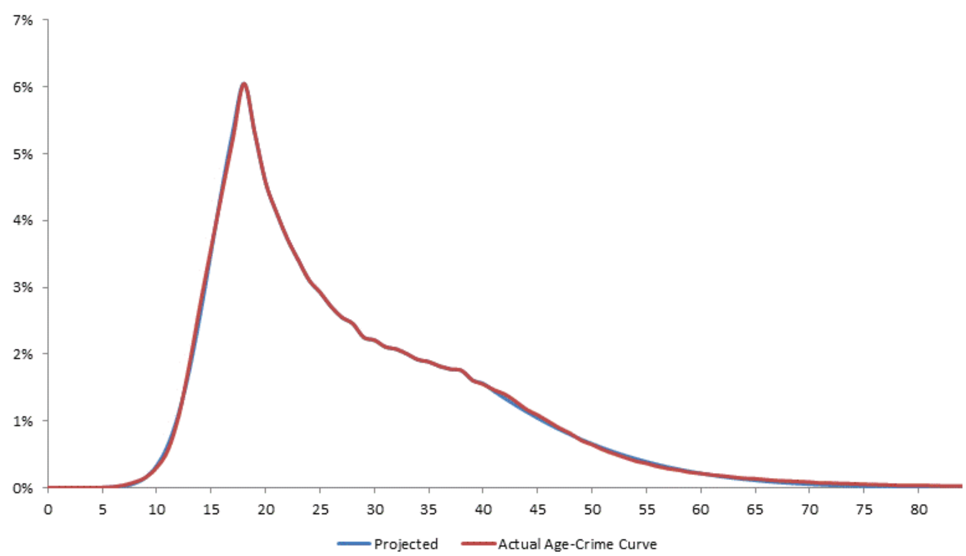
| Model | 0-18 | 19-45 | 46-98 | Total |
|---|---|---|---|---|
| Intercept (a) | -5 | 0.614 | -0.79 | |
| Slope (b) | 0.3316 | | 0.0548 | |
| | | | | |
| Constant | 13.776 | | | |
| SS(T) | .010922 | .018211 | .000501 | .029634 |
| SS(E) | .000006 | .000001 | .000002 | .000009 |
| **S.E.** | **.000570** | **.000240** | **.000349** | **.000710** |
| R Squared | .999465 | .999943 | .995629 | .999694 |

**Female Age Crime Curve Model Fit**

| Model | 0-18 | 19-45 | 46-98 | Total |
|---|---|---|---|---|
| Intercept (a) | -7.2 | | -0.9 | |
| Slope (b) | 0.55 | | 0.087 | |
| | | | | |
| Constant | 19.4 | | | |
| SS(T) | .007535 | .003728 | .000261 | .019283 |
| SS(E) | .000004 | .000000 | .000001 | .000005 |
| **S.E.** | **.000459** | **.000002** | **.000158** | **.000228** |
| R Squared | .999497 | 1.000000 | .995001 | .999736 |

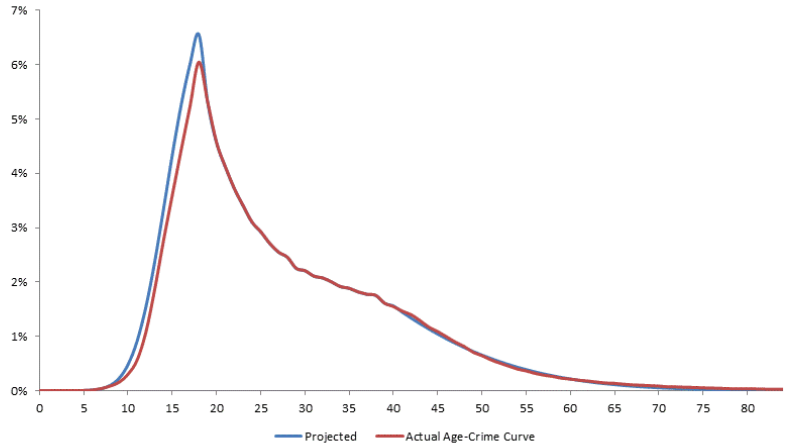
The process involved in creating a model fit was both visual and quantitative. To illustrate the visual nature of the process, the male model fit is shown in the chart below. Note that you can barely see the blue model plot behind the actual data from the age crime curve in red.

**Male Model Fit**

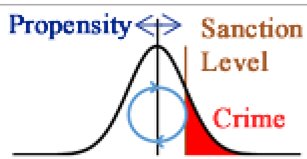



The process involved changing the values. Note that the values shown above went out to four decimal places. The model was sensitive to change out to that level of precision. To illustrate the extreme sensitivity to change, the slope from 0-18 was changed from .3316 to .35. (See table values above) Note how the curve changes shape. This model is a highly nonlinear model with a very high sensitivity to change.

**Male Model Fit With 0-18 Slope Adjusted from .3316 to .3500**



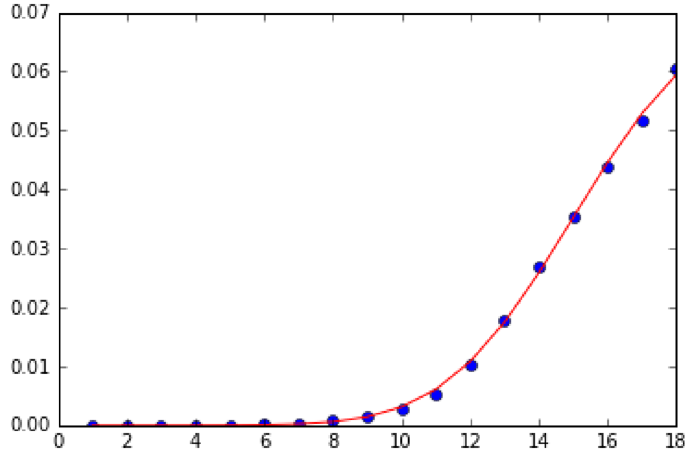

These results demonstrate that the age crime curve is probably the result of a series of normal propensity distributions that shift with age. Again, this is Case #3 (Reproduced Below). Propensity varies with age and sanctioning remains constant. As the shift in propensity occurs with age, the crime rate follows a sigmoid curve. This model works for the first and fifth features of the age crime curve. Now, the task is to explain the second, third, and fourth features.

| **Case #3: Sanctioning is Constant and Propensity Varies** | |
|---|---|
|   |   |
| In Case #3 the propensity level varies and sanctioning is constant. From looking at the model on the left, if the mean propensity ($\mu_P$) is not equal to the Z score at a particular sanctioning level ($Z_S$). The mean propensity is equal to the Z score minus a constant (C). | |

### *Testing the Model in Python*

I borrowed some code off the Internet for curve fitting in Python. I loaded the complete Python Spyder 3.0 scientific module and created a couple of sample datasets from the NIBRS age crime data. These files are available as a zipped file at http://www.thecriminologicalpuzzle.com/try-it-yourself/. There are a number of formulas tested. The utility plots the best curve fit along with the data points. A number of standard curves are tested. You can add your own fairly easily. The code provides the coefficient of determination (R Squared) and BIC and AIC values for comparison.

Plot of Crime Rate by Age from Python Curve Fit




It is interesting to note that the model fit for the normal curve with a linear z-score trajectory and a constant multiplier outperforms the standard normal curve with a linear Z-score trajectory and no constant multiplier. See below. Recall that a higher Coefficient of determination indicates a better model fit, and more negative BIC and AIC values indicate a better fit. The curve fitting utility was able to find a line with an $R^2$ value of 99.92 % when a constant multiplier of 1.36 was used in the model. Without the multiplier, the $R^2$ value dropped to 96.64%.

The explained variance without the multiplier is close to the explained variance with the multiplier, but the results suggest that the reported data points are 1.36 times lower than ideal. This could be due to the effects of missing data. That is, the actual crime rate could be 1.36 times (36%) higher than reported by NIBRS. There may be other possible explanations, but it seems logical that crime rates may be under reported. This explanation would be generally consistent with published literature that suggests that reported crime rates are lower than actual crime rates. Whether this difference is 36% is another question.

**Python Curve Fit Results for Male NIBRS Data**

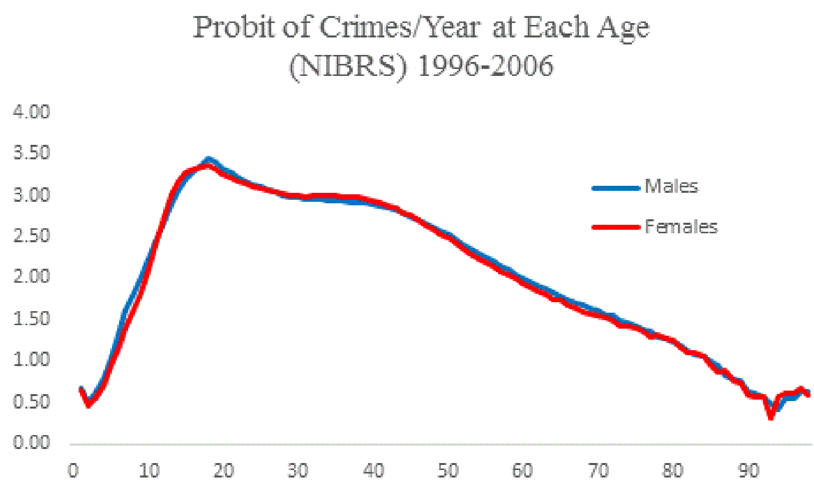
Formula with Constant: (p/(1/c)*norm.cdf(m*x + b))
Coefficient of Determination = 0.999236575117
Parameters 3
AIC = -212.472610164
BIC = -261.828186532

Formula without Constant: (p/norm.cdf(m*x + b))
Coefficient of Determination = 0.9664210804
Parameters = 2
AIC = -146.363507781
BIC = -196.609455908

## *Calculating the Probit Values for Males and Females*

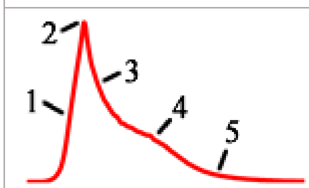
The probit of crimes by age can be calculated by calculating the quantile of the ratio of crimes at each age and adding five. This plot shows an even greater match between the male and female age crime curves. If the male probit is used to explain the female probit, the explained variance is 99.5%. Note that there are slight variations in the timing of the crime probits in the 0-18 age range. Males appear to have a slight early spurt and then females catch up and pass the males. This is again reversed when females peak earlier and males pass them. These features are not as noticeable without the probit plot.

**Probit of Crimes per Year by Age and Gender in US (NIBRS - 1996-2006)**




## *A Developmental Lag in the Capacity for Harm and Control*

The next problem was to explain the second, third, and fourth features of the age crime curve. This is challenging, but not impossible. It turns out that, once it is determined that the age crime curve is a sigmoid transformation of an age propensity curve, a developmental lag model explains all five features.

| **The Five Features of the Age Crime Curve** | |
|---|---|
|  | The age crime curve has five distinct features.<br>1. In the period from ages 0-18 there is a sharply rising curve.<br>2. At about age 18 (16 for females) there is a sharp reversal.<br>3. There is a curved descent from ages 18-30.<br>4. Crime picks back up slightly from ages 35-40<br>5. There is a gradual curved decline from about age 40 onward. |

The third finding is that the age crime curve appears to be the result of intersecting developmental trajectories. In order to explain this, a new theory of crime called a "capacity" theory will be developed. It will be suggested that crime is a function of the capacity to harm and the capacity to control. The capacity to harm is assumed to be related to a person's strength, and the capacity to control is assumed to be a function of mental capacity. Therefore, as strength increases, it increases the capacity to harm. As intelligence increases, it increases the capacity to control one's behavior, and thereby decreases the propensity for crime.

Using this model, the formula for $Z_{Age}$ should be able to be expressed as a linear function of strength and mental capacity by age as shown in Equation 29. In this model strength causes increases in propensity, and mental capacity causes decreases in propensity. Both strength and mental capacity are changing with age.

$$Z_{Age} = a + b_1 Strength_{(Age)} - b_2 Mental\ Capacity_{(Age)} \qquad \text{Equation 29}$$

Where $Z_{Age} =$ The Propensity for Crime at Each Age

a = Constant intercept

$b_1$ = Strength multiplier

$Strength_{(Age)}$ = Strength at each age

$b_2$ = Mental Capacity multiplier

$Mental\ Capacity_{(Age)}$ = Mental Capacity at each age

The mathematical form of the age crime curve then appears to be as shown in Equation 30.

$$Crime\ Rate_{Age} = \frac{1}{C}\Phi\,(a + b_1 Strength_{(Age)} - b_2 Mental\ Capacity_{(Age)}) \qquad \text{Equation 30}$$

When a developmental lag in the development of strength and mental capacity is assumed, and the results of the model are plotted, they appear to explain why there is a sharp transition in the age crime curve at around age 18. Various iterations of the model suggest that a five year lag in development seems to provide the best fit to the model.

This model is appealing for a variety of reasons. It could be that there is an evolutionary advantage to having young people who are willing to harm others. One could imagine young warriors going out to rape pillage and plunder before returning home with a bride and stolen riches to settle down in the village. This model bears further development.

### What does Development Look Like?

There are a number of problems with working with developmental data. Two of the more vexing are the 5 year aggregation problems, and the applicability of the measure. The first problem is the practice of five year aggregation. Much of the life-course developmental data is aggregated into 5 year periods. While this makes plotting easier, it creates problems matching the age crime curve to real data. The other problem is the applicability of the measure. A measure of works published or income level by age is interesting, but there are potential moderating variables that make this data partially suspect. To compound these two problems, there are often suspect measures plotted at five year intervals.

By combing the literature, one can get a general sense of the shapes of development. There is a lot of data regarding the 0-18 age range, and particularly school age children. Researchers working with K-12 students have a “captive” research pool and can run all sorts of tests to determine the levels of physical and mental development by age. The developmental data tends to be much sparser with adults.

The data from childhood is rather consistent. Babies start out with very little strength or intelligence. The can hardly move and can’t talk. They would get a score near zero on almost any adult strength or mental ability test. Their strength and mental abilities climb almost linearly until about age 18, with a gradual decline in the level of growth in strength in the later years.

Adult development is less well studied. Schaie conducted seven year studies of cohorts of various ages over a period of years and was able to get a broad picture of the levels of mental capacity over the live course. There would appear to be a gradual decline in mental ability as people age. Note that this method has been criticized because there could be cohort differences.

**Schaie Data on Mental Abilities**

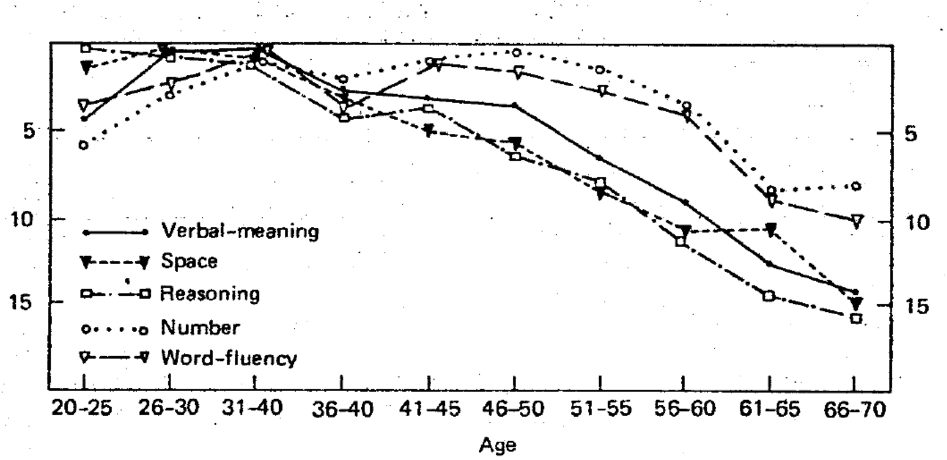



**Figure 6.2.** Performance differences on the primary mental abilities test from young adulthood to old age. (From Schaie, 1958)

Weschler (1972: Weschler's Measurment and Appraisal of Adult Intelligence- Fifth Edition) published the following. Intellegence seems to peak in the late 20s and declines thereafter. The five year gap in aggregation makes it difficlut to find the exact peak age.

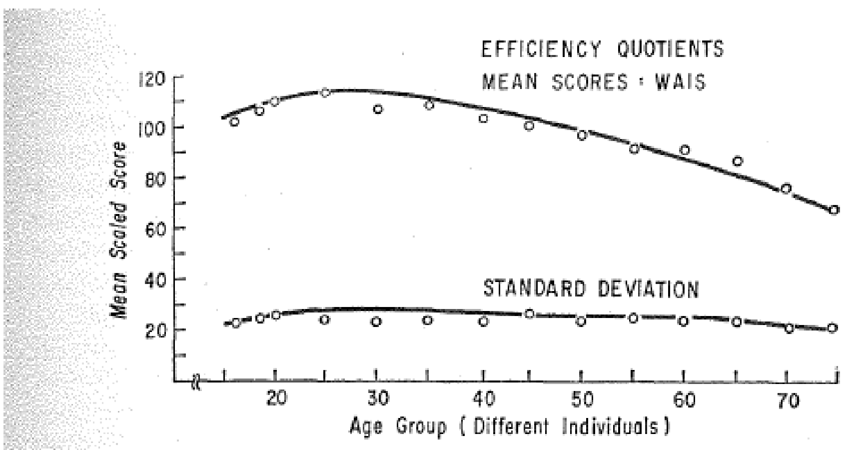



FIG. 4.1. Full Scale scores of the Wechsler Adult Intelligence Scale for ages 16 to 75 and over. These are *scaled* scores which, when used with Table 18 of the 1955 *Manual* for the different age groups, yield an Efficiency Quotient for that age group relative to the 20- to 34-year-old reference group sample. See Figure 10.1 for the comparable W-B I curve, and also Tables 10.4 and 10.3.

### Try it Yourself: Fitting Two Developmental Curves Together

This is another situation where you may want to try this yourself. I built a curve fitting model in Excel to fit hypothetical strength and mental capacity to an age propensity curve. The model first creates hypothetical strength and mental capacity trajectories, and then subtracts the mental capacity from the strength value at each age to create an age propensity curve. Then, there is a set of calculations to transform the age propensity curve to an age crime curve. This produces a set of four different curves that all have to fit together in a precise way to match the actual NIBRS age crime curve data.

#### *A Cumulative Gain/Loss Model of Development*

The Excel curve fitting model is based upon a cumulative gain/loss model. The developmental trajectories are set up with a general format as shown in Equation 31. The value at any time point is the value at the previous time point plus any gain/loss in the intervening period.

$$X(\text{Age}) = X(\text{Age} - 1) + \text{Gain/Loss} \qquad \text{Equation 31}$$

This is an additive model. Another way to think of this model is using a summation function. This is represented by Equation 32.

$$X(\text{Age}) = \text{Initial Condition} + \sum \text{Gains/Losses} \qquad \text{Equation 32}$$

There are four periods in the developmental models for both strength and mental capacity. This configuration appears to provide the best fit to the age propensity curve and age crime curve.

1. Steady gain
2. Transition (Decelerating gain)
3. Transition (Peak)
4. Transition (Accelerating loss)
5. Steadily accelerating loss

The model assumes that strength and mental capacity rise almost linearly in childhood and adolescence, transcribe some type of gentle deceleration curve in late adolescence and early adulthood, reach a peak, and then begin a gradually increasing period of loss in adulthood which reaches a steady state of increasing loss in late adulthood. The model provides places to change the slopes of the linear sections, the curve shapes, and the relative contributions of strength and mental capacity to the propensity levels.

The parameters for the male NIBRS age crime curve data that had the best fit are shown below. Strength appears to have a larger effect on the crime rate than mental capacity. The best fitting model had strength growing at .4 units per year and mental capacity growing at .25 units per year. The parameters are shown below. The deceleration and acceleration factors were added because it appeared that the declines in later adulthood were accelerating with age. It turned out that no adjustment was needed in the childhood years.

| | Strength | Mental Capacity |
|---|---|---|
| Growth Factor | .4000 | .2500 |
| Deceleration | .0000 | .0000 |
| Decline Factor | .0200 | .0200 |
| Acceleration | .0013 | .0009 |

The developmental transition curves were fit manually. A number of options were tried, and the model parameters shown below seemed to produce the best fit. I used a standard formula of steady gain or steadily increasing loss in all areas except the transition period. During the transition period, it was assumed that strength and mental capacity would stop growing be less each year until growth stopped completely at the peak, and then losses would start creating a period of decline. A “1” in the multiplier column indicates no transition from the base formulas. A value other than 1 indicates a period of transition. You can look at the cell values in the spreadsheet if you want to see what happened.

Strength increased at .4 units per year until age 15. Then, strength appeared to stop growing at a 10% slower rate per year beginning at age 16 until it stopped growing completely at age 25. Strength started declining at a 5% faster rate per year until it reached a period of gradually increasing decline in the years after age 43. The total transition period for strength from growth to decline lasted 28 years from 16 through 43.

The transition from growth to decline in mental capacity had a different pattern. The transition period was shorter, lasting only 14 years from 21 to 34. The transition values in the decreasing gain period were also not constant for mental capacity. It appears that the growth in mental capacity started slowing down at a gradually diminishing rate at age 21, finally reaching a period of no growth at age 30. The beginning of the decline period was more linear in nature.

The two trajectories in the calculated strength and mental capacity columns shown below were combined by subtracting the values for mental capacity from the values for strength. This produced a probit plot that used a slightly modified method of probits (P = Z + 5.1). The value 5.1 was used instead of the standard value of 5 in order to avoid negative values.

The modified probit was converted to a Z-score by subtracting 5.1. The Z-scores represent the age propensity curve. The age propensity curve was transformed into a projected age crime curve, and the projected age crime curve was compared with the actual age crime curve.

*Calculations for Strength and Mental Capacity Transitions*

| **Age** | **Strength Multiplier** | **Strength Calculated** | **Mental Capacity Multiplier** | **Mental Capacity Calculated** | **Modified Probit** | **Z-Score** | **Projected Age Crime Curve** | **Actual Age Crime Curve** |
|---|---|---|---|---|---|---|---|---|
| 14 | 1.00 | 6.0000 | 1.00 | 3.8000 | 3.0360 | -2.0640 | .0195 | .0270 |
| 15 | 1.00 | 6.4000 | 1.00 | 4.0500 | 3.2430 | -1.8570 | .0317 | .0355 |
| 16 | .90 | 6.7600 | 1.00 | 4.3000 | 3.3948 | -1.7052 | .0441 | .0438 |

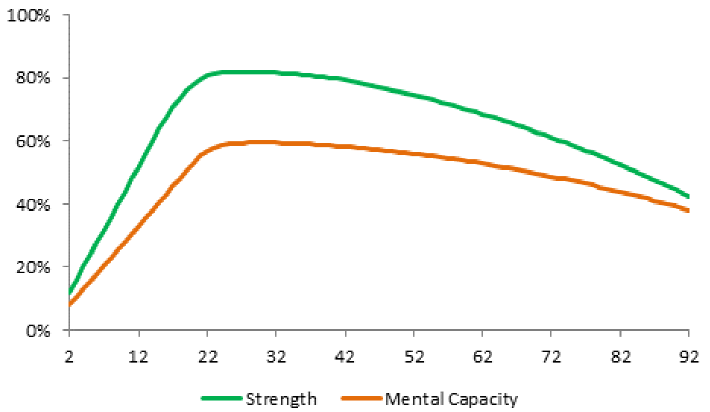
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 17 | .80 | 7.0800 | 1.00 | 4.5500 | 3.4914 | -1.6086 | .0539 | .0518 |
| 18 | .70 | 7.3600 | 1.00 | 4.8000 | 3.5328 | -1.5672 | .0585 | .0603 |
| 19 | .60 | 7.6000 | 1.00 | 5.0500 | 3.5190 | -1.5810 | .0569 | .0547 |
| 20 | .50 | 7.8000 | 1.00 | 5.3000 | 3.4500 | -1.6500 | .0495 | .0473 |
| 21 | .40 | 7.9600 | .90 | 5.5250 | 3.3603 | -1.7397 | .0410 | .0423 |
| 22 | .30 | 8.0800 | .60 | 5.6750 | 3.3189 | -1.7811 | .0374 | .0378 |
| 23 | .20 | 8.1600 | .45 | 5.7875 | 3.2741 | -1.8260 | .0339 | .0342 |
| 24 | .10 | 8.2000 | .32 | 5.8675 | 3.2189 | -1.8812 | .0300 | .0311 |
| 25 | .00 | 8.2000 | .14 | 5.9025 | 3.1706 | -1.9295 | .0268 | .0290 |
| 26 | .05 | 8.1990 | .08 | 5.9225 | 3.1416 | -1.9584 | .0251 | .0266 |
| 27 | .10 | 8.1969 | .06 | 5.9375 | 3.1179 | -1.9821 | .0237 | .0247 |
| 28 | .15 | 8.1935 | .04 | 5.9475 | 3.0995 | -2.0005 | .0227 | .0232 |
| 29 | .20 | 8.1887 | .02 | 5.9525 | 3.0860 | -2.0140 | .0220 | .0219 |
| 30 | .25 | 8.1824 | .00 | 5.9525 | 3.0773 | -2.0227 | .0216 | .0213 |
| 31 | .30 | 8.1745 | .20 | 5.9510 | 3.0683 | -2.0317 | .0211 | .0206 |
| 32 | .35 | 8.1647 | .40 | 5.9477 | 3.0595 | -2.0405 | .0206 | .0204 |
| 33 | .40 | 8.1531 | .60 | 5.9422 | 3.0510 | -2.0490 | .0202 | .0200 |
| 34 | .45 | 8.1394 | .80 | 5.9341 | 3.0433 | -2.0567 | .0199 | .0199 |
| 35 | .50 | 8.1236 | 1.00 | 5.9231 | 3.0366 | -2.0634 | .0195 | .0198 |
| 36 | .55 | 8.1054 | 1.00 | 5.9112 | 3.0280 | -2.0720 | .0191 | .0191 |
| 37 | .60 | 8.0848 | 1.00 | 5.8984 | 3.0173 | -2.0827 | .0186 | .0188 |
| 38 | .65 | 8.0617 | 1.00 | 5.8847 | 3.0042 | -2.0958 | .0181 | .0185 |
| 39 | .70 | 8.0359 | 1.00 | 5.8701 | 2.9887 | -2.1113 | .0174 | .0181 |
| 40 | .75 | 8.0072 | 1.00 | 5.8546 | 2.9706 | -2.1294 | .0166 | .0175 |
| 41 | .80 | 7.9756 | 1.00 | 5.8382 | 2.9496 | -2.1504 | .0158 | .0166 |
| 42 | .85 | 7.9409 | 1.00 | 5.8209 | 2.9256 | -2.1744 | .0148 | .0159 |
| 43 | .90 | 7.9030 | 1.00 | 5.8027 | 2.8985 | -2.2015 | .0138 | .0147 |
| 44 | 1.00 | 7.8596 | 1.00 | 5.7836 | 2.8649 | -2.2351 | .0127 | .0135 |

### *Seeing is Believing*

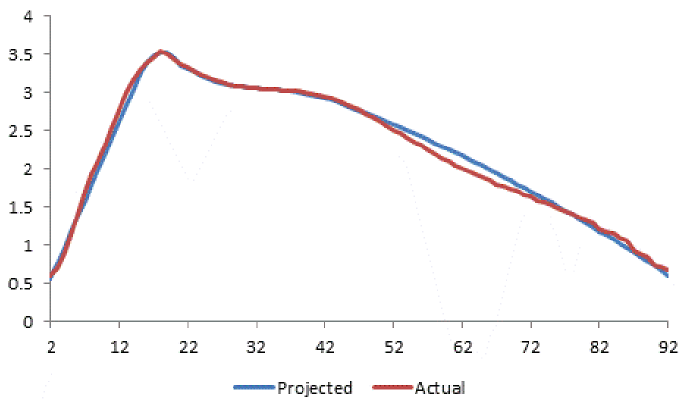
The process of curve fitting was largely a visual process.  The values were modified based upon some initial ideas of what these curves look like, and then the changes that occurred in the model were observed with each change in model parameters.  The model is nonlinear and small changes in some of the parameter produced large changes in the plots.  The modeling process involved observing three charts.

*Three Matching Plots*

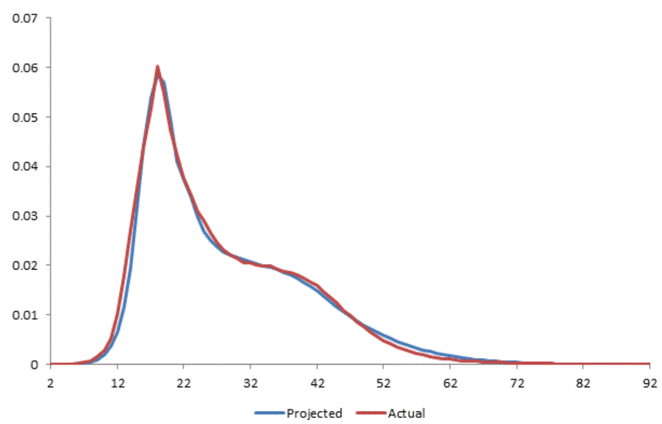
*Plot of Strength and Mental Capacity*




*Modified Probit Plot of Projected and Actual Age Propensity Curves*




*Projected and Actual Age Crime Curves*

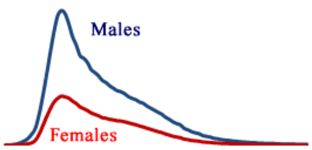


### *Human Development as a Function of Growth and Decline*

One of the interesting findings is that human development appears to be a nonlinear function of two variables, growth and decline. A person grows, stops growing, and then begins to decline. The declining process starts at zero, accelerates, and then reaches a steady state of accelerating decline. While working on the models of strength and mental capacity, the best fitting models appear to come from the assumption that strength starts to begin growing less and less about five years before the growth in mental capacity starts to decelerate. There seems to be a "transition period" between age 18 and 40 where people are starting to decline before they have finished growing. This developmental model seems to be worth exploring further.

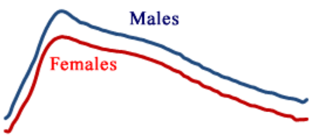
## *Tying it All Together: A Pictorial Guide to the Age Crime Curve*

1) The Age Crime Curves for Males and Females have Different Shapes




The age crime curves for males and females appear to have different shapes. In particular, the height of the male age crime curve is much higher than the female age crime curve.

2) The Age Propensity Curves are Almost Identical in Shape, Suggesting Developmental Causes

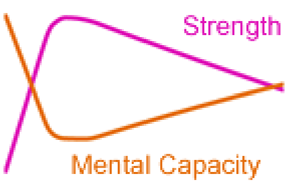



A Quantile Transformation of the age crime curve can be used to create the "Age Propensity Curve" [Propensity = $\boldsymbol{\Phi}^{-1}$(Crime Rate)]. The age propensity curves for males and females are almost identical in shape, with an offset in height. This suggests that developmental factors affect the shape and other factors affect the height of the propensity curves.

3) The Development of Mental Capacity Lags the Development of Strength

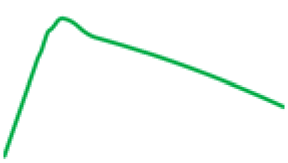

There is an approximately five year lag between the development of peak strength and peak mental capacity. If strength provides the capacity for crime and mental capacity provides the ability to control ones behavior, then the lag between the development of strength and mental capacity could cause the age propensity curve.

4) Flip the Pieces




In order to determine how the trajectories of strength and mental capacity interact to create the age propensity curve, the trajectory for mental capacity must be flipped and subtracted from the strength trajectory. The intersection of these curves explains the sharp transition in the age crime curve in late adolescence.

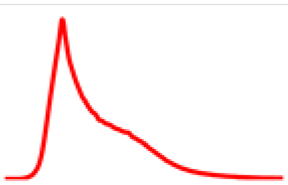
5) The Age Propensity Curve is a Function of Strength and Mental Capacity



The age propensity curve appears to be a linear function of strength and mental capacity. **Propensity = a + $b_1$*Strength – $b_2$*Mental capacity**

Note that the propensity for crime increases linearly and then transcribes a gradual curve before decreasing linearly over time. This shape is consistent with a developmental process.

6) The Age Crime Curve is a Sigmoid Normal Transform of the Age Propensity Curve



The age propensity curve can be transformed into the age crime curve using a normal transformation [Crime Rate = (Propensity)]. For some reason, a constant multiplier is needed to obtain the best fit. This suggests that the observed crime rate may be less than the real crime rate. The best fitting formula for the age crime curve in terms of strength and mental capacity is shown below.

$$Crime\ Rate_{Age} = \frac{1}{C}\,\Phi(a + b_1 * Strength_{(Age)} - b_2 * Mental\ Capacity_{(Age)})$$

After working for years to "fit" the age crime curve to a mathematical model, a very simple model was found that explained 99.995% of the variation in crime by age for both males and females in the age ranges from 0-18 and 40-85. When combined with some very basic theories about human development, this model also explains why there is such a sharp transition in crime rates at around age 18.

The mathematical model that will be used to explain the age crime curve involves a two-step process, combining two nonlinear dynamics. First, the sigmoid nature of the relationship between propensity and crime is used to create an "age propensity curve" and then a developmental lag model of the nonlinear dynamics of strength and mental capacity is used to explain the age propensity curve.

This model is highly nonlinear, since it involves two separate nonlinear processes. In working on the curve fitting for this model, it was found that a change of .001 units could cause the model to produce substantially different results. However, when conditions we exactly right, the model fits that actual age crime curve almost perfectly. The model explains the sharp transition from growth to decline in crime rates at age 18, and some of the other features of the crime rate over the entire life course.

The current nonlinear age crime model was developed independently, but after it was built, a literature review revealed that the basic elements of this model had been proposed by Quetelet (1833/1984) over 180 years ago. The literature review will begin with his work and then progress to some of the more contemporary work. Then, a set of procedures will be proposed for fitting the age crime curve model.

The mathematical model that is presented reveals some very precise values for a set of constants. The constants vary for males and females. There are also a set of very precise trajectories that are produced. It is not clear at this point, but the stability of these models seems to be somewhat questionable. Due to the nonlinear nature of the model, small differences can create large differences in outcome. In essence, one could argue that there is "sensitive dependence on initial conditions." The models are provided on the criminological puzzle web site with the hope that others will get involved with trying to replicate this work with other offender populations.

## Other Work on the Age Crime Curve

was found,

France had begun collecting national crime rate data in 1825. Quetelet's (1833/1984) had examined France's crime rate data and noted that the crime rates begin at zero in early childhood, rise to a peak in late adolescence and early adulthood, and then fall to near zero again in old age.

Quetelet (1833/1984) had proposed a developmental lag theory to explain the age crime curve. His proposed solution to the age crime curve puzzle is that strength and passion grow faster than reason. Crime rates climb in childhood because strength and passion are growing and reason has not had time to catch up. Once strength and passion stop growing and start declining, and reason catches up and keeps growing, crime rates drop in adulthood. He argued that the reasons for the age crime distribution were obvious to anyone who considered human development.

Quetelet (1833/1984) went on to show that strength matured before reason. He used data on strength and mental capacity over the life course to show

Quetelet's (1833/1984) work appears to have been largely ignored. His work on the age crime curve would seem to be one of the more important pieces of the criminological puzzle, and it seems to have been buried in the pile. For one thing, it was not translated into English until 1984. Hirschi and Gottfredson (1983) had brought parts of this work to the surface a year earlier, but do not seem to have noticed the theoretical work that Quetelet had done. As far as can be determined, no one seems to have cited his developmental lag theory about the reasons age crime curve.

suggested that this was one of the most difficult problems criminologists have had to deal with.

It will be suggested that the reason for the difficulty in solving the age crime curve is that two nonlinear processes are occurring at the same time. The first nonlinear process is the process creating sigmoid crime rates. The second nonlinear process is the process of development.

For some reason, his ideas were largely ignored.

When solving any good puzzle, it takes insight to figure out how the pieces fit together. Once the solution is found however, it easier to see how to assemble the puzzle, even though the methods used may have seemed illogical at the start. Once the solution to a tough puzzle is found, all that needs to be done is show others how the puzzle pieces fit together. Explaining how to solve the age crime curve puzzle appears to be almost as challenging as finding the solution in the first place.

## A Brief History of the Age Crime Curve

The term "age crime curve" was coined by Farrington (1986), and is used to describe the distribution of crimes by age at the population level. Quetelet (1831) appears to be the first to plot the peculiar shape of the age crime curve. He found that crime tends to rise rapidly from about age 10 to a peak in late adolescence, and then declines almost as rapidly in adulthood, with few people committing crimes in old age. The age crime curve has presented an ongoing puzzle for criminologists. Hirschi and Gottfredson (1983) noted that the age distribution of crime "easily qualifies as the most difficult fact in the field" (p. 552). Other commentators tend to agree, and no general consensus has emerged about why crime varies with age (Loeber, 2012; Loeber, & Farrington, 2012; Farrington, 1986; 2003; Osgood, 2005; 2012; Piquero, Farrington, & Blumstein, 2003; 2007; Sweeten, Piquero, & Steinberg, 2013; Telesca Erosheva, Kreager, & Matsueda, 2012).

Quetelet (1831) appears to be the first to have proposed a solution to the age crime curve puzzle. He suggested that the propensity for crime varied over the life course because of changes in strength, passion, and reason. He argued that the propensity for crime is low at the beginning and end of the life course, when strength and passion are low and the propensity for crime is high in late adolescence when strength and passion are at their peak. He noted that the propensity for crime subsided in adulthood because reason was increasing, and strength and passion had stopped increasing. He suggested that these facts lead to the obvious conclusion that changes in strength, passion, and reason must create the age distribution of crime. In an extensive literature search, it does not appear that anyone has cited this theory, and so this would seem to be a buried piece of the criminological puzzle.

The solution to the age crime curve puzzle that was proposed by Quetelet (1831) has not received much attention. Quetelet (1835) noted that for 200 years before 1835, scientists had neglected the analysis of the effects of life course changes in physical and mental capacity on behavior. He argued that scientists must pay closer attention to the timing of developmental changes in physical and mental capacity and determine when these reached their peak. His admonitions have been largely ignored in the 180 years since 1835 until now. If one takes his estimate of a 200 year vacuum in research on strength/mental capacity interaction with behavior, and adds almost 200 years more, this leads to an estimated 400 years that scientists have almost completely ignored the ties between life course changes in strength, mental capacity, and behavior.

Since Quetelet (1831) proposed his theory, few people have looked at the effect of strength on behavior. One exception is provided by Steffensmeier and Allan (1995), who plotted the age crime curve against the strength curve over the life course. They demonstrated that while increases in strength could possibly explain the buildup in crime in adolescence, high levels of strength persist until mid adulthood, and therefore declines in strength alone cannot account for the sharp drop in crime rates in early adulthood.

The analysis by Steffensmeier and Allan (1995) fails to take into account the effect of increases in mental capacity. In the model proposed by Quetelet (1831), increases in mental capacity in adulthood, after strength has stopped growing, provide the missing piece of the puzzle that cause the reduction in crime in early adulthood. Quetelet (1831) suggested that declines in strength with increasing age cause further declines in crime in late adulthood.

Several other authors (Adams, 1997; Gove, 1985; Greenberg, 1977) have suggested that physical strength is one factor that affects the level of crime with age. They note that crimes require a certain level of physical strength and agility, and this factor is changing over the life span. Therefore, it would be reasonable to assume that the amount of strength seen at different ages could be related in some fashion to the level of crime committed.

There have been several other proposed solutions to the age crime curve including maturation (Glueck, & Glueck, 1937); social maturation (Moffitt, 1993); a peak in “thrill and adventure seeking” (Baldwin, 1985; see Hirschi, & Gottfredson, 1985 for a reply); a peak in testosterone levels (Gove, 1985; Ellis and Walsh, 2000; Walsh, 2009); a change in identity with the transition to adulthood (Giordano, Cernkovich, & Rudolph, 2002; Laub, & Sampson, 2001; 2003; Maruna, 2001; Shover, 1996); the desire to find a mate and produce children (Kanazawa, 2003; Kanazawa, & Still, 2000); adults getting married, getting a job, or joining the military (Sampson, & Laub, 1993); moral development , cognitive development and/or changes in physical capacity (Adams, 1997); and immaturity of judgment in adolescence (Cauffman, & Steinberg, 2000). There have been few tests of these proposed models that have shown a close relationship between these factors and the age distribution of crime, and so the attempts to determine the cause of the age crime curve have remained largely speculative.

One of the more influential discussions of the age crime curve was provided by Hirschi and Gottfredson (1983). They proposed three important hypotheses regarding the age crime curve, suggesting that 1) the age crime curve appears to be “invariant” for people of different genders, races, or social conditions, 2) “inexplicable” with variables available to criminologists, and 3) the factors causing crime to vary with age appear to “non-interactive” with other criminological variables (Sweeten et al., 2013; Tittle, & Grasmick, 1997). They suggested that crime rates go down in adulthood because of “maturational reform” or some other equivalent unexplained process (p. 564). They argued that criminologists simply accept that crime varies with age and that there is no need for criminologists to explain why.

It would appear that most criminologists have generally followed the advice of Hirschi and Gottfredson (1983) to ignore the effects of age on crime. Age is generally included in most studies as a control variable that need not be explained. For example, Agnew and White (1992) found that a control variable for age had a positive linear relationship with delinquency for subjects 18 and under. Burton, Cullen, Evans, and Dunaway (1994) found that a control variable for age had a negative linear relationship with crime for subjects 18 and over. Burton et al. (1994) did not see a need to comment on the fact that they found that increasing age is a protective factor for adults, while Agnew and White (1992) found that age is a risk factor for adolescents, because this flip flop in the effect of age on crime is an unremarkable finding. The effects of age on crime were considered to be completely separate from the study of the criminological concept of strain. The assumption appears to be that strain is a criminological risk factor for both adolescents and adults, irrespective of the reversal of the effects of changes in age on changes in the crime rate.

Not all theorists have agreed with Hirschi and Gottfredson (1983) that we should ignore the effects of age on crime. Vold, Bernard, and Snipes (2002) report that Hirschi and Gottfredson's (1983) statements about the age distribution of crime resulted in a "great debate" among criminologists (pp. 284-291). They suggest that the great debate boiled down to two positions, a "criminal propensity" position, and a "criminal career" position. Hirschi and Gottfredson defended the criminal propensity position and criminal career researchers such as Blumstein, Cohen, Farrington and others defended a criminal career position.

Hirschi and Gottfredson (1983; 1985a, 1985b, 1990; Gottfredson, & Hirschi, 1986; 1987; 1988; 1990) argued that between individual differences in crime rates are caused by stable individual differences in criminal propensity. The term criminal propensity can mean a number of things, so it will be defined as "the likelihood of committing a crime." The general argument of Hirschi and Gottfredson (1983, Gottfredson, & Hirschi, 1990) is that rank order differences in criminal propensity are stable over the life course and therefore, age has the same effect on the behavior of offenders and non-offenders. Age can be ignored as a criminological variable because it has little to do with other factors causing between individual differences in criminal propensity.

The criminal career position was taken by Blumstein, Cohen, and Farrington and others (Blumstein, Cohen, Farrington, 1988a; 1988b; Blumstein, & Cohen, 1987; Blumstein, Cohen, Roth, & Visher, 1986; Piquero et al., 2003; 2007). Criminal career advocates argued that there is considerable variation in the shapes of individual criminal careers, and there needs to be a search for the reasons there are such different trajectories. Blumstein, Farrington, and Moitra (1985) suggested that the focus of criminal career research should be on determining why some people do not appear to commit crimes (innocents), others commit few and then desist (desisters), and others persist in committing many crimes over the life course (persisters). In order to determine why there are innocents, desisters, and persisters, it is necessary to study factors such as participation, starting age, rate of offending, career length, age of desistance, and crime seriousness over the life course (Blumstein, et al., 1986). Criminal career researchers argue that the causes of crime and desistance may be different at different ages and the rank order distribution of criminal propensity can change over time. They suggest that there is a need for longitudinal research to determine the effects of circumstances on individual crime rates.

Rowe, Osgood, and Nicewander (1990) proposed an intermediate solution to the great debate. They proposed a latent trait model of criminal propensity to explain why some people do not commit crimes, some commit few, and some commit many. They suggested that criminal propensity can be considered to be a latent trait, which is an unobservable phenomenon that can be inferred from observing other behaviors. They hypothesized that criminal propensity is normally distributed in the population and that the level of criminal activity should grow exponentially as criminal propensity rises. When they plotted the level of crimes predicted by their model against the level of crimes actually committed, they found a close correlation.

Britt (1992) also tried to find a solution to the age crime curve puzzle, suggesting that the reason that the age crime curve was invariant between different groups as suggested by Hirschi and Gottfredson (1983), was because the age crime curve had the same “mathematical form,” regardless of the group differences in other factors. He tested gamma and log-normal distributions with the age distributions for a number of crime types and found that both mathematical models had high explained variances when explaining the shapes of various crime distributions. Greenburg (1994) suggested that a modified chi-square distribution provided a better fit than the gamma distribution for the individual crime age crime curve data. An important point raised by Greenburg (1994) was that many different mathematical models might be found that explain the age crime curve, but these models are problematic if there is no theoretical basis for their use.

A non-theoretical approach to finding a fit with the age crime curve was attempted by Sweeten et al. (2013). They attempted a test of the inexplicability hypothesis proposed by Hirschi and Gottfredson (1983). This hypothesis is that the age crime curve is inexplicable with current criminological variables. They tested the relationship between 40 of the more significant variables related to crime and the age distribution of crime. The statistical model was able to explain 69% of the variation in crime from ages 15-25 that would have been explained by age alone. The authors conclude that more data is needed if a better model fit is to be obtained. They suggest that a simple solution to the age crime curve is probably not possible.

Macleod, Grove, and Farrington (2012) developed a more theoretical model that appears to explain the age crime curve. They suggested that there is a large non-criminal group in the population and a small number of criminal groups. The proportions of people in these groups are relatively constant across cohorts. Criminality and recidivism are also considered to be constant functions within individuals. They built a mathematical model with several proposed variables related to participation rates, recidivism rates, and other factors, and the resulting calculated distribution appears to have a fairly close correspondence with the age crime curve. The model developed by Macleod et al (2012) seems to be tautological because it uses variables derived from crime rates as independent variables predicting crime by age. This appears to be problematic from a theoretical standpoint.

From the preceding review, it seems that a plausible theoretical and mathematical model of the age crime curve is still needed. The following discussions are intended to further the discussion on this topic. It would appear that the pieces are available to the solution to the age crime curve puzzle, but that no one appears to have fit them together. The proposed solution adds several new ideas. To reduce the complexity of the topic, a pictorial representation of the problem will be presented. It is hoped that this will help make this problem and its solution easier to understand.

## A Proposed Solution

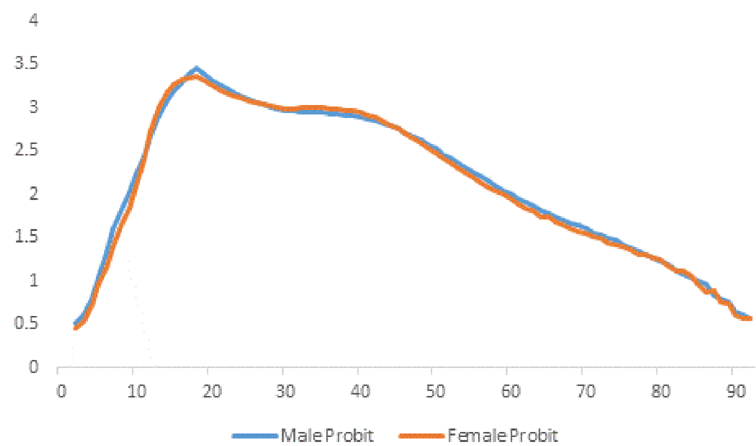
The proposed solution to the age crime curve puzzle requires that two sets of two pieces each be fit together. The first set of two pieces is the nonlinear relationship between propensity, sanctioning, and crime rates. The second set of two pieces is the relationship between the nonlinear trajectories of strength and mental capacity over the life course. Fitting these two sets of pieces together is a very challenging project, but theoretical models based upon the model that will be presented appear to explain almost all of the variance in the age crime curve.

## *The Age Propensity Curve*

The first step in the solution is to recognize that crime rates will follow a sigmoid response curve with changes in propensity. Therefore, to estimate the changes in propensity over the life-course, the age crime curve needs to be converted to an "age propensity curve" by using the quantile of the crime rate. This creates a Z score. If one adds five to the result, a "probit" is created that is nothing more than a Z score shifted up 5 points.

The plot of male and female probits for ages 2-92 is shown below. These are the age propensity curves for males and females. Note that they are almost identical in size and shape.

**Age Propensity Curves for Males and Females 2-92**




One of the issues with the relationship between propensity and crime rates is the relationship is nonlinear. That means that a small shift in propensity may produce a large shift in the crime rate. To illustrate this phenomenon, the normal distributions for the average person are plotted from ages 2 to 92. A proposed sanction threshold is plotted in red. The age propensity curve is changing relatively slowly. However, the crime rate is the area under the propensity distribution to the right of the sanction threshold. This area increases much more rapidly as the crime rates gets closer to 50%.

# Chapter 15: The Effects of Incapacitation

The purpose of this chapter is to provide an examination of the predictions of the criminological puzzle model with respect to incapacitation. Early in the 1970s, criminologists (re)discovered that a small fraction of the population was committing a large fraction of the crimes (Wolfgang et al., 1972). This finding was followed by the development of a mathematical model of the criminal career (Avi-Itzhak, & Shinnar 1973; Shinnar, & Shinnar, 1975), along with the concept of "selective incapacitation" (Greenberg, 1975). Although these developments were not solely responsible for the events that followed, they contributed to a shift in focus of sanctioning efforts toward incapacitation of offenders.

Two general trends have occurred. From the early 1970s, the levels of incarceration rose from historical levels of about 100 persons per 100,000 to about 600 persons per 100,000. In the mid-1990s, crime rates began to drop. These two patterns are difficult to reconcile. First, it more incarceration reduces crime, why did crime rates keep rising during the initial incarceration buildup? Second, post mid-1990s, if crime rates are dropping, why was incarceration climbing?

Recent studies have tried to make some sense of these patterns. The consensus seems to be that early increases in incarceration led to decreases in crime, but further increases in incarceration had little effect on crime. The reasons why this occurred are not well understood.

It would appear that the crime model proposed as a solution to the criminological puzzle could shed some light on this problem. The criminological puzzle model predicts that incapacitation should produce diminishing returns. This is a function of a normal distribution with asymmetric sanctions. The response is sigmoid, which means that it will take greater and greater amounts of incapacitation to achieve less and less of an effect. To illustrate this, it is necessary to look at the ideal model.

## The Failure of the Career Criminal Model

The career criminal model was used to create a justification for increased levels of incarceration. The logic behind this model was that there are career criminals with a steady state of offending. The propensity of these individuals was calculated by creating an average lambda, which was the rate of offending. The effectiveness of increases in incapacitation should be linear in nature.

Research has indicated however, that this model has not produced the intended effects. Historically, from about 1930 to 1970, the incarceration rate had been about 100 offenders per 100,000 citizens. Then, there was a push to get offenders off the streets, and incarceration levels climbed to about 700 offenders per 100,000.

The data suggests that the initial increases in incarceration levels had an effect. That is, there seemed to be a decrease in the overall crime rate. However, further increases in incarceration levels seemed to have little effect. Why?

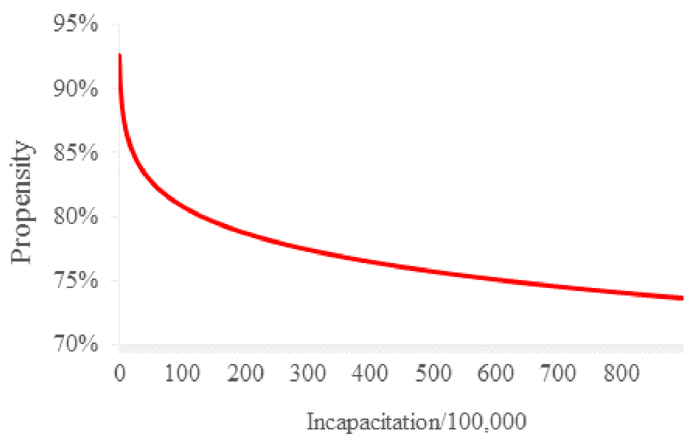
## An Ideal Model of Incapacitation

In an ideal world, the people with the highest propensity to harm others would be incarcerated. This would give society the most "bang for its buck." If criminal propensity is normally distributed, the most harmful people would be on the highest end of the propensity distribution. This premise is similar to the one used in the career criminal model, but the distribution assumptions are different. The career criminal model proposes a taxonomy, while the normal distribution model proposes a bell shaped distribution.

The normal propensity model provides a different prediction regarding the effects of increased incapacitation. Rather than assuming a linear increase in effectiveness, the normal propensity model predicts a nonlinear increase with rapidly diminishing returns.

The normal propensity model provides some interesting predictions. We can begin with the ideal scenario. Let's assume for the moment that a given society was 100% effective in incarcerating the most dangerous individuals. In this model society, the policy makers want to estimate the effects of increases in the incarceration. One could develop a model to predict what the propensity of the next batch of criminal would be, given that the people with the higher levels of propensity are already incarcerated. The model produces the following curve.

**The Ideal Incapacitation Model**




In the ideal model, the people with the highest propensity will be incarcerated first. The offenders in the top 19.1% propensity percentile will be incarcerated by the time the incarceration rate reaches 100 offenders per 100,000 citizens. Increasing the incarceration level from 100 to 200 prisoners means that the prisoner population will include the people in the top 21.2% propensity percentile. This is only an increase of 2.1% and represents a 90% drop in increased efficiency from 100 to 200 prisoners (19.1% to 2.1%). The increase in efficiency drops off almost linearly after that. It seems clear from this model that incarcerating 100 to 200 offenders per 100,000 would be the most cost effective use of resources.

| **Inmates per 100,000** | **Maximum Propensity Percentile** | **Increase in Maximum Propensity** |
|---:|---:|---:|
| 100 | 19.1% | 19.1% |
| 200 | 21.2% | 2.1% |
| 300 | 22.5% | 1.3% |
| 400 | 23.5% | 1.0% |
| 500 | 24.2% | 0.8% |
| 600 | 24.9% | 0.6% |
| 700 | 25.4% | 0.5% |
| 800 | 25.9% | 0.5% |

## Caution: Actual Results May Vary

It is important to recognize that the ideal model assumes 100% efficiency in capturing the people with the highest propensity to harm others. This is probably never going to be possible, and so some inefficiency needs to be built into the model.

That said, this model seems to show why the increases in incarceration have had diminishing returns. If the population propensity is normally distributed, the level of efficiency from increased incarceration should drop rapidly when the incarceration levels increase beyond 100 offenders per 100,000.

# Chapter 16: The Baby Boom Crime Bump and Crime Drop

Crime rates rose and fell

# Chapter 17: Conclusion

There is a need to look closely at the present theoretical orientations, methods being used, and practices being proposed by criminologists. The single factor theory, taxonomies, and simple trajectory models do not adequately represent reality. This causes problems when trying to understand phenomena such as the age crime curve or the effects of sanctioning. The alternative solution is to look at more complex models. These more complex models can be confusing if not developed carefully. Each piece needs to be examined singly before the model can be assembled.

An attempt was made to try to point out the bigger issues and the progression of ideas. It was suggested that the criminological puzzle must be assembled in a systematic "piece by piece" fashion.

1) There are many factors that cause crime.
2) The propensity PDF is normal.
3) The individual propensity trajectories are complex.
4) Sanctioning is an asymmetric selection process.
5) The crime rate CDF is sigmoid with changes in propensity or sanctioning.
6) Quantile functions can help create propensity and sanctioning models.
7) Development is a function of growth and decline.
8) The age-propensity curve is caused by a developmental lag between strength and mental capacity.
9) The sigmoid crime rate function turns the age propensity curve into the age crime curve.
10) Increases in sanctioning can be expected to have rapidly diminishing returns.
11) The age structure of society can have positive and negative effects on the crime rate.

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# Appendixes

## Appendix B: Quetelet (1848; pp. 90-97)

Translator's Note: The following excerpt was translated into English using Google Translate. The translation may not be 100% accurate, but it seems to make sense. Some of the phrases sound a little odd, which may be due to the archaic nature of the writings. For example, the "law of accidental errors" can be assumed to be something related to the central limit theorem and the normal distribution. However, the terminology related to the normal distribution did not come into popular use until the early 1900s. If any French speakers would like to help proof this, please let me know. The link to both versions is on thecriminologicalpuzzle.com.

### The social system and laws that govern it.

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### Section II: Chapter 5- English Version

Observation teaches us that during our lifetime, we suffer very pronounced changes and that each of our moral character develops gradually, so as to reach a peak. But this, at what age should you place it? Is it possible then to determine, for different periods of life, the relative values of each of our trends?

I tried to address these issues and to understand that to assign the law of development of each of our moral standing, so much the observation methods we miss that series of experiments done right. Not only we can determine the influence of age, but also that gender, professions, races, and anything that can identify differences in the human species.

These kinds of reviews are based on the theory of averages; It should

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not however accept in an absolute sense. So that, in Belgium, the tendency for marriage to have more intensity age of 36, it should not be concluded that all men of this age have indeed more likely to marry than those of a different age. I speak here only of the average man, be abstract, that is, in a way, in a state of equilibrium between all individuals of the same age.

If we relate this to any average man will require the design to different times of the year, as passing successively through all the nuances that undergoes the group of individuals it represents. The trend that marriage will be more or less energetic, will deviate more or less than the average trend; but the differences are even more rare, they are older; and these differences will be subject to the number and size, to the law of accidental causes. This curious result follows from what I said earlier about the constant repetition of the same facts, which cannot take place without destroying effects of accidental causes; now this destruction actually operates, all years in the same manner.

The man, the moral faculties, is, like the physical, subject to

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deviations larger or smaller average condition; and it undergoes oscillations around this average, follow the general law governing all the fluctuations that can undergo a series of events under the influence of accidental causes.

However, I emphasize a restriction; is that social facts cannot remain the same so far as the company remains under the influence of the same causes.

This is the trend in the crime and the tendency to marriage: its variations are subject to very specific fluctuations. Conceivably all men as likely to get, in some way, in hostility to the laws. In some, this trend can, even in its excesses, remain so low, that we should be considered void; among others, on the contrary, it is highly developed, and there is every risk that this will be manifested by acts more or less objectionable. These two extremes are generally very rare. In others, and they are the most numerous, this trend exist in narrow limits; This does not mean, however, that the majority of men will have a decided inclination to crime. It is necessary to leave no doubt about it.

The man, the moral faculties, is, like the physical, subject to deviations larger or smaller average condition; and it undergoes oscillations around this average, follow the general law governing all the fluctuations that can undergo a series of events under the influence of accidental causes.

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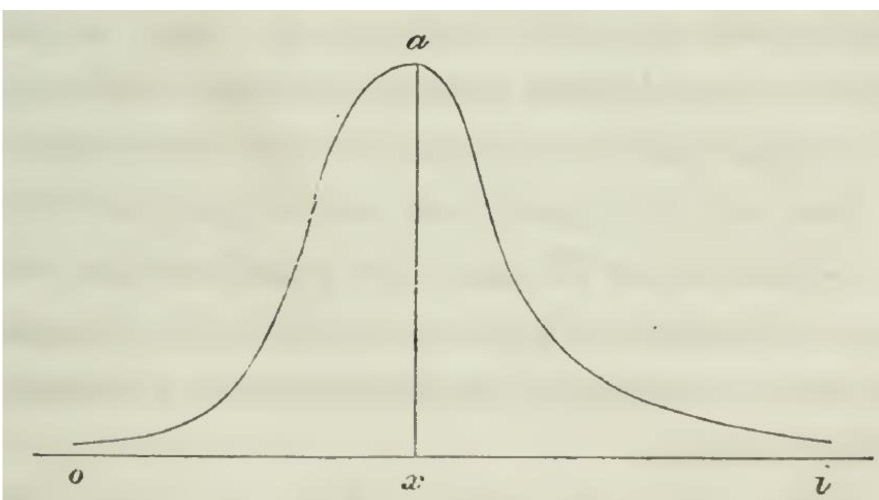
Suppose that attention is fixed on all men 30 years. We conceive that there is in each of them, a certain possibility, (word tendency would say too much perhaps about it) to get in hostility with the laws. This possibility, however small it is, admits of the lower levels until it can be absolutely void; as well, it can grow up to become equal to certainty. Thus, some men certainly will not conflict with the law; while, in others, on the contrary, the opposition will manifest. The other men in greater numbers, will approach more or less than average; the following figure will be able to make this distribution more sensitive to the eyes.




At the point o, the likelihood of crime, addiction or crime, is absolutely nil. The likelihood increases as one moves away

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to move to the right, and it becomes certainty to i. The curved line oai by its deviations from the straight line oi, shows the number of people corresponding to each probability.

The same oai line, which discloses how men distribute themselves among them, in point of propensity to crime, affects, again, the shape of the curve accidental causes. It should be noted that we find, for the moral qualities, the same law that regulates the distribution of men in the relationship of elevated height, body weight, strength and other physical attributes. I must warn, however, that I am not presenting this result as deduced directly observed facts; I even think that it will never be possible to demonstrate anything in this regard, other than by way of induction.

Anyway, the curve is good for men 30 years is not the same at other times of life: its shape has to change along with the maximum and the extent of its limits.

These analogies go further and become applicable to the individual. Let me explain: we assume that every man has a ten-

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dency to break the law. However, this trend did not remain constantly the same; it varies sometimes more, sometimes less; and if it was possible to assess the value, amid all the changes it undergoes, we would find that it is also subject to the law of accidental causes, which governs somehow our entire universe. The limits and shape of the curve changes with different men: for some, the probability of committing the crime is up certainty, while for the greatest number, it is very low, even in its large gaps.

One should not conclude from what I have just said that all the actions of man, that all trends are subject to fixed laws; and that as a result, I suppose free will absolutely annihilated. To avoid any misunderstanding in this regard, some explanation will be even more necessary as they may throw light on the question of free will, one of the most difficult and interesting that we can meet in studies we occupy.

If, to take one example, we believe in man, his tendency to crime, we first notice that this trend depends on the particular organization,

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the education he received, the circumstances in which he found himself, and his free will which I willingly grant the greatest influence to change its inclinations. It may therefore, if it wants to become other than it is. However, it is conceivable that our different faculties end up putting in a steady state, and by contracting them some reports, we seek to divest as possible. This is the state that will best suit our organization; accidental causes may alter, but we always tend to return. Unforeseen events can excite our passions lead us to evil even as we rise above ourselves; these are accidental causes that make us more or less oscillate around our fair condition; and the very fact that changes are accomplished under their influence, our different states are subject to the law of possibility. As for free will, far from throwing disturbances in the series of phenomena which take place with the admirable regularity, it prevents the contrary, in that it tightens the limits within which manifest changes in our different inclinations .

The energy with which our agency

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tends to paralyze the effects of accidental causes, is somehow related to the power of our reason. Whatever the circumstances in which he finds himself, the wise deviates only slightly from the average state in which he believes will have to tighten. It is only in entirely abandoned men to the fury of their passions, we see these abrupt transitions, true reflections of all external causes that affect them.

Thus, free will, far from creating an obstacle to the regular production of social phenomena, favor the opposite. In people who would be trained as wise, annually provide the most constant return of the same facts. This may explain what first seemed a paradox is to say that social phenomena influenced by the free will of man, shall, from year to year, with more regularity than the phenomena purely influenced by material and accidental causes.

For example,

, but there are some curious problems that arise.

For example, if I assume that there are many causes of crime, the central limit theorem would predict that the propensity for crime is normally distributed.

I have been working with a normal model, and there seems to be evidence that criminal propensity is normally distributed.

Does a normal distribution support the theory that there are many causes of crime?

The continuous model can be approached from two directions.

Many causes implies a normal distribution.

A normal distribution implies many causes.

Is this tautological or are these facts congruent?

I am a criminology Ph.D. student at the University of Cincinnati. I am coming to this discipline quite late in life. I had received a B.A. in Physics in 1974 and had worked as a computer programmer, technician, and web page designer for about 25 years. I began volunteering in the local jail in 2002 and became interested why people commit crimes. I obtained a Master's degree in Criminal Justice in 2007 and began work on my doctoral degree in Criminology and Criminal Justice in 2010.

Since I began working to discover the root causes of criminal behavior, I have become more and more disenchanted with the current scientific methods being used to study crime and criminal behavior. There seem to be some misconceptions about the nature of criminal propensity.

For example, a popular criminological model is the career criminal model. In this model, there are ordinary citizens and career criminals that spend their lives committing crimes. This model is a taxonomic model with criminals and non-criminals defined as two types of people. I have been working to develop a model where criminal propensity is normally distributed. In the normal model, criminal propensity is continuous, with a few outliers who commit many crimes.

Another popular criminological model is the criminal career model, which is different from the career criminal model. In this model, people begin a criminal career and continue for some time until they desist from crime. For my Master's thesis, I studied the risk levels of offenders over time, and I found that the risk levels fluctuate. This suggests that a criminal career is a fiction. People move in and out of criminal behavior like a person with a smoking habit that is trying to quit. Sometimes they smoke and sometimes they don't. Sometimes they commit crimes and sometimes they don't.

Moving on, most criminological theories take a position that one thing causes crime. For example, Gottfredson and Hirschi (1990) wrote a book called "A General Theory of Crime" that proposes that crime is caused by low self-control. There are perhaps one hundred various theories that each propose a different cause of crime. Each theory has some degree of empirical support.

The common characteristic of each of these approaches is a desire to find simple solutions. Taxonomies are simpler than continuous distributions. Constant offending is simpler than fluctuation. Single cause models are simpler than multiple cause models.

The problem with each of these approaches is that they do not fit reality. Criminal propensity is continuous. Criminal propensity fluctuates. There are many causes of crime.

Here is where I begin to have some problems. I have developed a set of theoretical propositions. I am trying to put these together and you can see some of the pieces on my web site at http://thecriminologicalpuzzle.com

I begin with the proposition that crime rates are a bivariate function of the propensity of individuals to harm others, and the propensity of societies to sanction acts that are perceived to be harmful.

The propensity to commit crimes is massively multivariate, has complex dynamics, and is normally distributed.

The propensity to sanction harmful behaviors is asymmetric.

Therefore, crime rates will follow a sigmoid path with changes in mean propensity or the sanctioning level.

This may seem like an odd model, but when I apply this to the age distribution of crime,

As I try to frame this into a causal framework, I run into some problems.