

**ATTACKS ON TRANSIT DRIVERS
AS A FUNCTION OF AMBIENT TEMPERATURE**

by

Jonathan Yasayko

B.A. (Honours), Simon Fraser University, 2007

Thesis in Partial Fulfillment
of the Requirements for the Degree of
Master of Arts

in the
School of Criminology
Faculty of Arts and Social Sciences

© Jonathan Yasayko 2010
SIMON FRASER UNIVERSITY
Spring 2010

All rights reserved.

However, in accordance with the *Copyright Act of Canada*, this work may be reproduced, without authorization, under the conditions for *Fair Dealing*. Therefore, limited reproduction of this work for the purposes of private study, research, criticism, review and news reporting is likely to be in accordance with the law, particularly if cited appropriately.



SIMON FRASER UNIVERSITY
LIBRARY

Declaration of Partial Copyright Licence

The author, whose copyright is declared on the title page of this work, has granted to Simon Fraser University the right to lend this thesis, project or extended essay to users of the Simon Fraser University Library, and to make partial or single copies only for such users or in response to a request from the library of any other university, or other educational institution, on its own behalf or for one of its users.

The author has further granted permission to Simon Fraser University to keep or make a digital copy for use in its circulating collection (currently available to the public at the "Institutional Repository" link of the SFU Library website <www.lib.sfu.ca> at: <<http://ir.lib.sfu.ca/handle/1892/112>>) and, without changing the content, to translate the thesis/project or extended essays, if technically possible, to any medium or format for the purpose of preservation of the digital work.

The author has further agreed that permission for multiple copying of this work for scholarly purposes may be granted by either the author or the Dean of Graduate Studies.

It is understood that copying or publication of this work for financial gain shall not be allowed without the author's written permission.

Permission for public performance, or limited permission for private scholarly use, of any multimedia materials forming part of this work, may have been granted by the author. This information may be found on the separately catalogued multimedia material and in the signed Partial Copyright Licence.

While licensing SFU to permit the above uses, the author retains copyright in the thesis, project or extended essays, including the right to change the work for subsequent purposes, including editing and publishing the work in whole or in part, and licensing other parties, as the author may desire.

The original Partial Copyright Licence attesting to these terms, and signed by this author, may be found in the original bound copy of this work, retained in the Simon Fraser University Archive.

Simon Fraser University Library
Burnaby, BC, Canada

STATEMENT OF ETHICS APPROVAL

The author, whose name appears on the title page of this work, has obtained, for the research described in this work, either:

(a) Human research ethics approval from the Simon Fraser University Office of Research Ethics,

or

(b) Advance approval of the animal care protocol from the University Animal Care Committee of Simon Fraser University;

or has conducted the research

(c) as a co-investigator, collaborator or research assistant in a research project approved in advance,

or

(d) as a member of a course approved in advance for minimal risk human research, by the Office of Research Ethics.

A copy of the approval letter has been filed at the Theses Office of the University Library at the time of submission of this thesis or project.

The original application for approval and letter of approval are filed with the relevant offices. Inquiries may be directed to those authorities.

Simon Fraser University Library
Simon Fraser University
Burnaby, BC, Canada

Abstract

This study investigated attacks against transit drivers as a function of ambient temperatures from January 2006 to December 31st, 2007 in Metro Vancouver, Canada. Nonaggressive violence was differentiated from aggressive violence. Univariate, correlational analysis and ordinary least squares regression were used to determine if temperature was positively associated with attacks of violent aggression, but not nonaggressive violence.

Results revealed a nonsignificant seasonal effect for violent aggression and a positive and substantial relationship between mean monthly temperature and violent aggression. No significant relationship was observed at the weekly level, possibly due to methodological limitations. The results provided some support for the heat aggression hypothesis and are interpreted using Boyanowsky's Ecs-TC syndrome as a theoretical guide. Results also revealed support for differentiating incidents of nonaggressive violence from aggressive violence. The potential implications and future directions for research on temperature and aggression in light of climate change are discussed.

Keywords: temperature; violence; aggression; violent aggression

*In loving memory of my father Larry Gene Yasayko
(October 16th, 1948 - December 31st, 2009)*

Acknowledgements

I extend the greatest gratitude to Dr. Ehor Boyanowsky who has provided me with continual support and encouragement throughout my intellectual endeavours at Simon Fraser University and throughout the development of my masters thesis. Thank you to Dr. Brantingham and Dr. Takaro for volunteering to be on my committee and providing me with exemplary feedback. Thank you to my family—in particular, my father Larry, mother Gloria, brother Ryan, and sister-in-law Brianna, without your support this thesis would not have been possible. Thank you to all of my friends who have been there for emotional support, and to the academic professionals who have recognized and encouraged my talents along the way. Also, I would like to extend my sincere gratitude to Joanie Wolfe who played a special role in assisting me with the final editing and formatting of my thesis. Lastly, but most importantly, thank you to my love, Amanda, for your love, patience and support for my academic and personal goals.

Table of Contents

Approval.....	ii
Abstract.....	iii
Dedication.....	iv
Acknowledgements.....	v
Table of Contents.....	vi
List of Tables.....	viii
List of Figures.....	viii
List of Abbreviations.....	ix

CHAPTER 1. Temperature and Aggression 1

1.1. Introduction.....	1
1.2. Historical Background.....	3
1.2.1. Early Research.....	4
1.2.2. Turning Points in Thought.....	6
1.3. Current Directions.....	7
1.3.1. Time Period Studies.....	7
1.3.2. Concomitant Heat Effects/Laboratory Studies.....	9
1.3.3. Geographic Region Studies.....	10

CHAPTER 2. Differentiating between Violence and Aggression..... 12

2.1. Defining Aggression.....	12
2.2. Violence versus Aggression.....	12

CHAPTER 3. Theoretical Approaches 14

3.1. Heat Hypothesis.....	15
3.2. Routine Activities Theory.....	18
3.3. Negative Affect Escape.....	19
3.4. Psychophysiology.....	20
3.5. Criticisms of Current Approaches.....	21
3.5.1. Time Period Studies.....	21
3.5.2. Laboratory Studies.....	22
3.5.3. Geographic Region Studies.....	23
3.6. Linear versus Curvilinear Debate.....	23
3.7. Integrating Perspectives.....	25
3.7.1. Ecs-TC Syndrome.....	27

CHAPTER 4. The Present Study: Aggression as a Function of Ambient Temperature 31

4.1. Research Questions and Hypotheses.....	32
4.1.1. Warmer Seasons and Aggression.....	32
4.1.2. Warmer Months and Aggression.....	34
4.1.3. Warmer Weeks and Aggression.....	34
4.1.4. Number of Passengers and Attacks against Drivers.....	35

CHAPTER 5. Methodology.....	36
5.1. Variables	36
5.1.1. Independent Variables: Climate Data	36
5.1.2. Dependent Variables: Attack Data	37
5.1.3. Control Variable: Ridership	38
CHAPTER 6. Univariate, Correlational, and Regression Analyses	39
6.1. Current Study	39
6.2. Preliminary Analyses	39
6.3. Descriptive Statistics	40
6.4. Results	43
6.4.1. Warmer Seasons and Aggression.....	43
6.4.2. Warmer Months and Aggression.....	46
6.4.3. Warmer Weeks and Aggression.....	48
6.4.4. Number of Passengers and Attacks against Drivers.....	49
CHAPTER 7. Discussions and Future Directions	51
7.1. Discussion	51
7.1.1. Warmer Seasons and Violent Aggression	51
7.1.2. Warmer Months and Violent Aggression	52
7.1.3. Warmer Weeks and Violent Aggression	52
7.1.4. Number of Passengers and Attacks against Drivers.....	53
7.1.5. Additional Analyses.....	54
7.1.5.1 Warmer Seasons.....	54
7.1.5.2 Warmer Months	54
7.1.5.3 Warmer Weeks.....	55
7.1.5.4 Number of Passengers	55
7.2. Theory: Ecs-TC Syndrome	56
7.3. Limitations	59
7.4. Implications and Future Directions.....	60
7.4.1. General Criminological Theory.....	61
7.4.2. Societal Policy.....	62
References	64
Appendices	73
Appendix A. General Affective Aggression Model	74
Appendix B. Select Line Graphs for 2006-2008	75
Appendix C. Annual Mean Temperatures in Vancouver from 1984 to 2008	78

List of Tables

Table 1.	Seasonal Descriptive Statistics for Attacks against Bus Drivers	41
Table 2.	Monthly Descriptive Statistics for the Main Explanatory and Dependent Variables	42
Table 3.	Weekly Descriptive Statistics for the Main Explanatory and Dependent Variables.....	42
Table 4.	Seasonal 1-way ANOVA of Attacks against Bus Drivers	43
Table 5.	Monthly Bivariate Correlations for the Explanatory and Dependent Variables.....	46
Table 6.	Weekly Bivariate Correlations for the Explanatory and Dependent Variables.....	48
Table 7.	Monthly Ridership and Temperature Correlated with Raw Violence Data.....	49

List of Figures

Figure 1.	Line graph Depicting the Relationship between Temperature and Assault (Levels 1-3) in Vancouver between 2001 and 2005.....	2
Figure 2.	Line Graph Depicting the Relationship between Temperature and Assault (Levels 1-3) in Montreal between 2001 and 2005	2
Figure 3.	Line Graph Depicting the Relationship between Temperature and Assault (Levels 1-3) in Toronto between 2001 and 2005.....	3
Figure 4.	Seasonal Assault with a Weapon Rate	44
Figure 5.	Seasonal Nonaggressive Violence, Aggressive Violence, and Total Violence Rates.....	45
Figure 6.	Line Graph Depicting the Relationship between Mean Monthly Temperature and Aggressive Violence Rate.....	47
Figure 7.	Line Graph Depicting the Relationship between Mean Monthly Temperature and Monthly Assault with a Weapon Rate.....	48

List of Abbreviations

ANOVA	analysis-of-variance
Ecs-TC	emotional cognitive stress under thermoregulatory conflict
GAAM	General Affective Aggression Model
HAH	heat aggression hypothesis
NAE	negative affect escape theory
OLS	ordinary least squares
RAT	routine activities theory
SCV	southern culture of violence
USEPA	US Environmental Protection Agency

CHAPTER 1.

Temperature and Aggression

1.1. Introduction

The spectre of global warming has sparked concerns around the world, including potential social and health impacts on human populations that may occur as a result of increasing climatic temperature and weather extremes. A report by the Pacific Institute for Climate Solutions has indicated that “climate change will act on the health of British Columbians directly through physical and biological pathways and, indirectly through complex socio-economic and environmental pathways” (Ostry, Ogborn, Takaro, Bassil, & Allen, 2008, p. 3). Moreover, temperature extremes have been increasingly occurring in BC in the last few decades (BC Ministry of Environment, 2007). Such impacts are not solely restricted to British Columbia, as there are serious implications for Canada and the rest of the global community. There is a pressing need to formulate adaptive strategies in response to climate change, and research frameworks need to be developed to address the problems it will create, one of which concerns mental health (Ostry et al., 2008). It is important that research identify the impact that climate change may have on the mental health of individuals and communities at large. There exists an abundance of evidence pointing towards the adverse affects on humans experiencing temperature extremes. One potential concern is the effect on the rate of aggressive behaviour and the violent crime that results from it. Previous research conducted by Yasayko (2007) reported a positive and significant linear relationship between temperature and the incidence of violent criminal assault (Levels 1-3) in 8 out of 11 major Canadian cities between 2001 and 2005. A portion of those results are presented in Figures 1-3.

Figure 1. Line graph Depicting the Relationship between Temperature and Assault (Levels 1-3) in Vancouver from 2001 and 2005

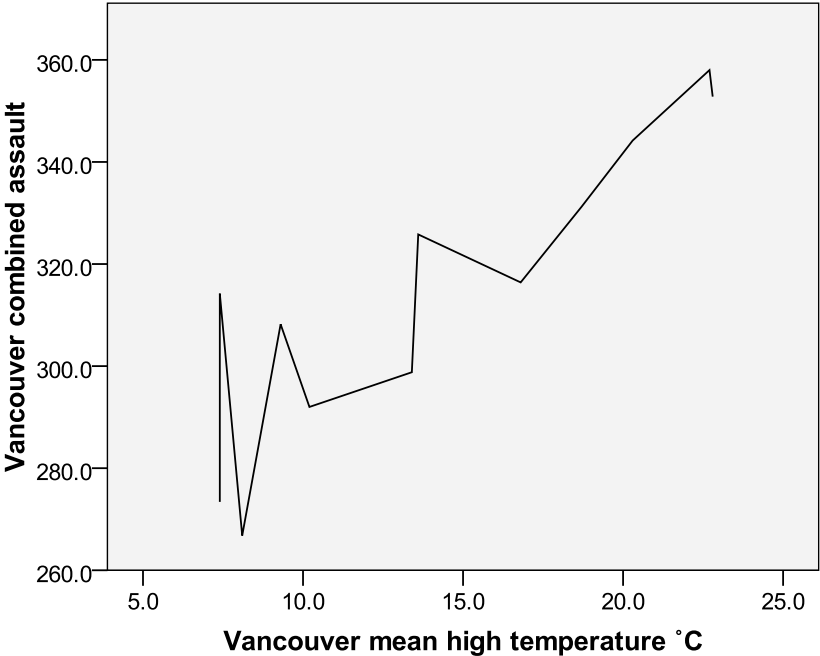


Figure 2. Line Graph Depicting the Relationship between Temperature and Assault (Levels 1-3) in Montreal from 2001 and 2005

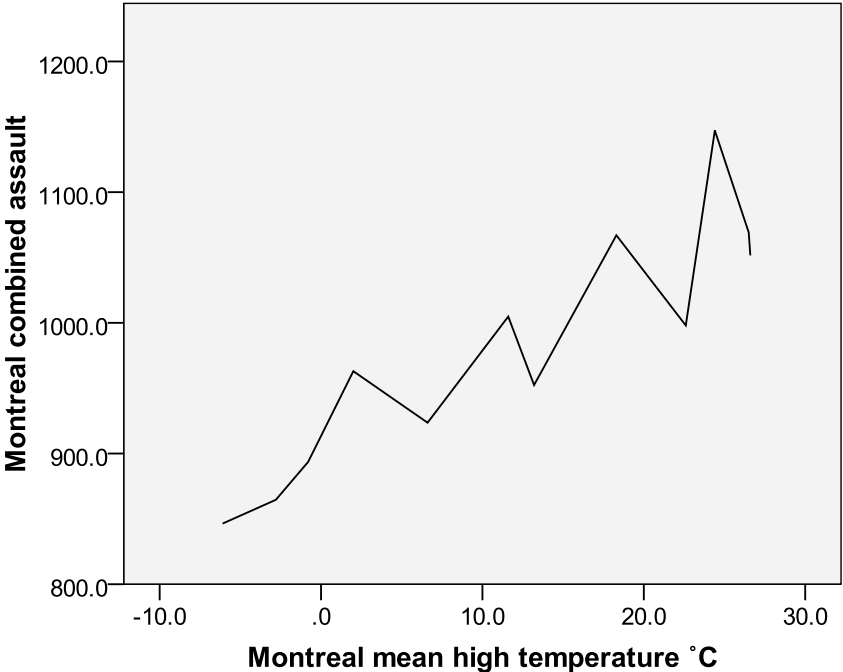
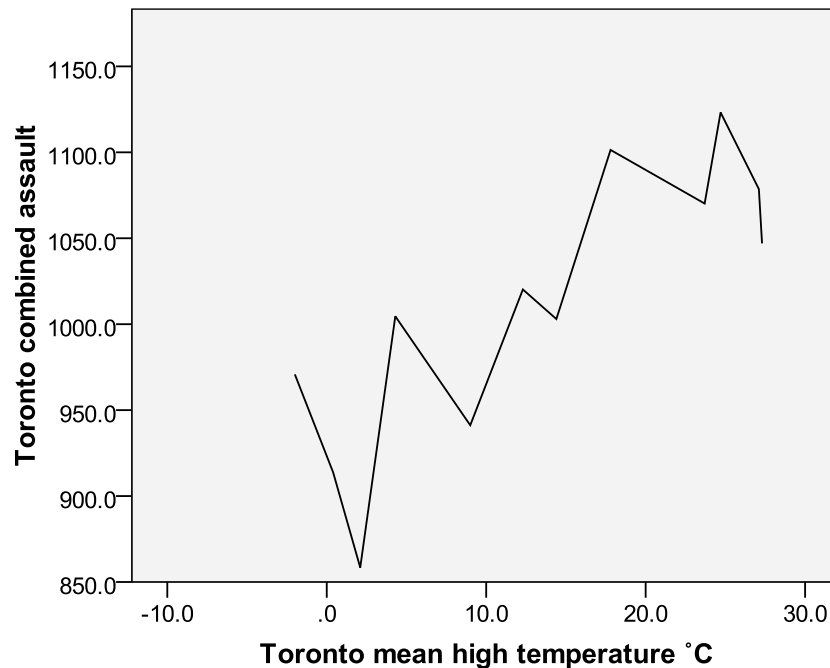


Figure 3. Line Graph Depicting the Relationship between Temperature and Assault (Levels 1-3) in Toronto from 2001 and 2005



The results depict a positive and significant linear relationship between environmental temperature in Canada's three largest cities: Vancouver ($r = .426$, $p < .01$), Montreal ($r = .672$, $p < .01$), and Toronto ($r = .239$, $p < .05$). The current study attempts to expand upon the results in Yasayko's study (2007) by controlling for changes in routine activities during different periods of the year and by formally operationalizing a definition of aggression for studying violent crime in heat.

1.2. Historical Background

It has long been documented that people become frustrated or angry when subjected to uncomfortably hot temperatures. Research has identified a strong correlation between ambient temperature and the incidence of violent aggression. Empirical studies have consistently revealed that hotter geographic regions have higher rates of violent crime (Anderson & Anderson, 1996; Van de Vliert, Schwartz, Huismans, Hofstede, & Daan, 1999). In fact, in the realm of idiom and language, a large array of

common metaphors reflects this observation, including: “my blood is boiling”, “steaming”, “hot-headed”, “hot-tempered”, “hot under the collar” and “in the heat of the moment”. Moreover, in response to angry individuals, people often say “you need to cool down” or “chill out” (Lee & Ross, 1989), while at other times, offering praise to those that remain “cool and collected” when involved in situations where there is potential for interpersonal or emotional conflict. A mixed bag of explanations at different levels of analysis has been offered to explain that connection in order to identify the causal mechanisms involved in precipitating violent human aggression in hot environments.

This study tested the relationship by examining and differentiating incidents of nonaggressive violence from aggressive violence against transit drivers from Coast Mountain Bus Company based on the model proposed by Boyanowsky (1999). First, it is necessary to examine the current perspectives in the temperature-aggression literature in order to determine whether one can reach from those findings any conclusions that will help predict the effects of global warming on the mental health of individuals worldwide. Therefore a review of the historical and current research literature that has tested the relationship between ambient temperature and the incidence of violent aggression must be undertaken.

1.2.1. Early Research

Environmental influences on human behaviour have been studied as part of the positivist tradition within criminology in order to define and measure criminal behaviour with empirical objectivity. That school of thought replaced the social philosophies of the classical school of criminology propounding human behaviour to be a rational and calculated product of free will.

In 1833, Quetelet was one of the first scholars to adopt an empirical approach to studying the link between temperature and violent crime resulting in his *thermic law of delinquency*. He was also the first person to employ statistics in the study of crime (Harries, 1980; Sylvester, 1972). Quetelet asserted that both seasons and climate influence an individual's “propensity” to commit crime, pointing out property crimes were least frequent in the summer, when crimes against the person were most frequent: “the

violence of the passions predominating in the summer excites to more frequent personal collisions” (quoted in Sylvester, 1972, p. 35).

Soon thereafter Kropotkin proposed that temperature and humidity are both important in precipitating violent crime (Cohen, 1941). In addition, another early scholar, Leffingwell (1892), examined the relationship between heat and violent crime by looking at the incidence of violent crime during four quarters of the year, while Lombroso (1899) devised his own set of quantitative studies testing seasonal, as well as geographic fluctuations of crime. Lombroso has often been targeted as a scapegoat by critics of biological research on crime, while his important contributions to the study of positive, or empirical, criminology have been largely and even, perhaps, purposely ignored (Lombroso, 1911/1972). Lombroso stated that “physiology and statistics show that most human functions are subject to the influence of heat; it is to be expected, then, that excessive heat will have its effect upon the human mind” (p. 2). Other propositions put forth by Lombroso continue to be supported today, particularly those pertaining to the potential influence that moderate temperature may have on facilitating criminal behaviour. For example, Lombroso proposed that when attempting to understand the underlying mechanisms responsible for triggering aggression in heat:

the influence which is most apt to produce a disposition toward rebellion and crime is that of a relatively moderate degree of heat...heat excites the nervous centers as alcohol does, without, however, arriving at the point of producing apathy. (1911/1972, p. 3)

More pointedly, Lombroso (1911/1972) points to “meteoric causes” as being important predisposing factors to the manifestation of criminal acts of an impulsive nature:

excessively high temperature and rapid barometric changes, while predisposing epileptics to convulsive seizures and the insane to uneasiness, restlessness, and noisy outbreaks, encourage quarrels, brawls, and stabbing affrays. To the same reason may be ascribed the prevalence during the hot months, of rape, homicide, insurrections, and revolts. In comparing statistics of criminality in France with those of the variations in temperature, Ferri noted an increase in crimes of violence during the warmer years. An examination of European and American statistics shows that the number of homicides decreases as we pass from hot to cooler climates. Holzendorf calculates that the number of murders committed in the Southern States of North America is fifteen times greater

than those committed in the Northern States. A low temperature, on the contrary, has the effect of increasing the number of crimes against property, due to increased need. (quoted in Lombroso, 1911/1972, p. 145)

Research on temperature-aggression continued to evolve after Lombroso's time through the use of more advanced statistical tools and theoretical assumptions. The development of research techniques and strategies enabled researchers to produce empirical findings at a much more rapid pace. Many of the findings supported the notion of a positive relationship between environmental temperature and the higher incidence of violent aggression. Supporting Lombroso's (1911/1972) contention, other scholars proposed that the temperature-aggression relationship may be a result of seasonal climatic variations producing a direct physiochemical effect in humans that subsequently influences their behaviour (Gaedeken, 1909). Building on those ideas, a few decades later, Huntington (1945) asserted that certain climates facilitate the development of cultural organization specific to those geographical regions.

1.2.2. *Turning Points in Thought*

Nevertheless, scientific and theoretical momentum gradually declined and research on temperature-violence fell out of favour due to the discomfort created in the context of the Aryan racial superiority theories propounded by the Nazi government in Germany and hostility towards deterministic propositions generally during a critical time when Marxist sociology was gaining widespread popularity (Boyanowsky, 1999). Nonetheless, interest was renewed in the late 1960s when the United States Riot Commission reported that most of the rioting in 1967 occurred on days when the temperature climbed to above 80°F (Cohn, 1990). In 17 cities where riots occurred, 15 experienced higher than normal temperatures at the time mass violence erupted (Goranson & King, 1970). Furthermore, in eight of those same 15 cities the rioting continued for more than 2 days when the temperature remained correspondingly hot. The seven other cities experienced relatively shorter periods of rioting, in direct relation to simultaneous declines in ambient temperature. Similar findings were cited by Brockes and Burkeman (2001) who indicated that between the mid-1970s and mid-1980s, most rioting in Britain had reportedly occurred during the hottest days of the summer season.

Some social scientists criticized those findings, arguing that there were important social factors involved in precipitating those riots. Boyanowsky (2007), however, pointedly adds “such political criticism missed the point: no one denied that the poor, or the discriminated against are not the first to experience the harshest brunt of environmental stresses—few riots occur in the poshest neighborhoods even during heat waves” (p. 2). From that period forward, research has predominantly supported a positive linear relationship between ambient temperature and the incidence of violent crime (Feldman & Jarmon, 1979; Michael & Zumppe, 1983a, 1983b; Rotton & Frey, 1985). Those new findings led to an explosion of interest in the heat-crime phenomenon and to new research and statistical approaches for studying it.

1.3. Current Directions

The most recent research examining the influence of temperature on violent aggression falls within an approach that Anderson and Anderson (1998) refer to as the “triangulation” or “multiple operationism” approach (p. 261), that comprises three types of approaches: (a) *time period effect*, studies examining the link between heat and crime over different periods of time (i.e., days, weeks, months and years); (b) *concomitant heat effect*, controlled experiments that examine the effects of temperature on aggression simultaneously; and finally (c) *geographic region effect*, experiments showing increased aggression in hotter geographical locals (discussed in detail in Anderson, 2001, pp. 33-36). The results drawn from such studies have provided support for the relationship between temperature and violent aggression. Furthermore, there are benefits to using triangulation as Anderson and Anderson (1998) indicate that “when the results of tests from several perspectives converge on the same answer, confidence grows” (pp. 260-261). A brief description and some examples of each of the three main approaches follow.

1.3.1. Time Period Studies

Time period studies are one of the most common analyses conducted for testing the relationship between temperature and aggression. Specifically, such studies are designed to test aggression temporally as a function of temperature over different

periods of time: hours, days, weeks, months, seasons/quarters, and years. A recent time period study presented by Anderson (2001) observed that there are:

more murders and assaults in the United States during the summer than other seasons of the year; hot summers produce a bigger increase in violence than cooler summers; and violence rates are higher in hotter years than in cooler years even when various statistical controls are used. (p. 34)

Another time-period analysis was performed by Michael and Zumpe (1986) to test temperature and rates of domestic violence between intimate partners. Based on 27,000 reports from women abused by their male partners they found that there were statistically significant annual rhythms of abuse correlated to ambient temperatures found at the locations where the abuse had occurred. The researchers concluded that their “findings support the hypothesis that violence by men toward women increases in summer independently of any major seasonal changes in the opportunity for contact between perpetrator and victim” (p. 637).

Time period studies have produced results with important social implications. For example, Anderson, Anderson, Dorr, DeNeve, and Flanagan (2000) examined yearly temperature averages from 1950-1997 for 50 major US cities and observed: “for each 1°F increase in average temperature, the United States experienced 4.58 additional murders/assault crimes per 100,000 population” (p. 123). Given that the US currently has a population of over 300 million people, that statistic equates to 13,740 additional violent crimes per 1°F increase in annual mean temperature. Those findings have important implications with respect to global warming.

The studies described above are only a small sample of dozens of time period studies that have produced positive results for various theories on temperature and aggression (discussed later). Moreover, although time period studies do not measure temperature and aggression simultaneously, but rather aggression carried over from one time to another within a predetermined time period (Anderson, 1989), they nonetheless provide evidence for the temperature-aggression connection and increase the validity of arguments for that relationship when combined with other statistical level approaches, such as concomitant and geographic studies.

1.3.2. Concomitant Heat Effects/Laboratory Studies

According to Anderson and Anderson (1998), “concomitant studies of the temperature-aggression hypothesis are actually a specific subcategory of time period studies” (p. 280), but rather than measuring temperature and the occurrence of aggression over a defined time period such studies measure temperature and aggression simultaneously. Anderson adds that evidence garnered from such studies yields the best support for the temperature-aggression relationship because they are measured more directly, although they have not always produced consistent findings or interpretations.

Concomitant studies are often carried out either in naturalistic settings or through laboratory experiments (Anderson & Anderson, 1998), however, studies of the latter type are more frequently used as they allow experimenters to manually control temperature (Anderson, 1989) and other undesirable extraneous variables. One example of a concomitant study that took place in a naturalistic setting was a study of driver aggression. Kenrick and MacFarlane (1986) correlated the temperature humidity discomfort index with driver aggression and discovered a positive and linear relationship. The study was conducted by first stopping a vehicle in front of another at a red light and recording the environmental temperature of the area. When the traffic light turned green they purposely kept the vehicle stationary and then documented the length of time it took for the vehicle behind to honk the horn, the number of times it was honked, and the duration of the honks. Following many trials those three factors were combined to depict driver aggressiveness. The researchers found a relationship between temperature and the reduced time it took drivers to honk their horn, and the number and duration of honks. Furthermore, a statistically significant relationship was found when the researchers controlled for the possibility of air-conditioning by only counting vehicles with their window down; an indication that the car was not equipped with a functioning air-conditioning system.

Concomitant studies conducted in laboratory settings have also produced evidence for the temperature-aggression relationship. One of the earliest laboratory studies was conducted by Boyanowsky, Young, and Bailly (1972) as they attempted to identify a more direct link between temperature and human inclinations to aggress. In

the experiment the researchers exposed each research subject to one of three preset ambient room temperatures: 10°C (cold), 20°C (warm), or 30°C (hot). The subjects were then required to complete a task where they would be given oral feedback concerning their performance by an unknown assistant of the researcher. The feedback was pre-taped by the experimenter and was purposely intended to be insulting. Each participant was then given an opportunity to respond to the insulting feedback by administering a number of painful shocks in retaliation. The number of shocks that a participant gave was used to measure their level of affective aggression. The researchers reported that the participants in the hot and cold rooms gave a significantly higher frequency of shocks in comparison to those in the warm or comfortable room temperature. The results of Boyanowsky and his collaborators' (1972) laboratory study suggest that people may respond to hot and cold ambient temperatures similarly, but those exposed to hot temperatures have the most potential to become violently aggressive because it is more difficult for an individual to control his/her comfort level in hot environments since they are more difficult to avoid and adapt to than are cold environments.

1.3.3. *Geographic Region Studies*

Lastly, in addition to studying temperature-aggression simultaneously, human adaptation to climatic conditions has important implications when it comes to understanding rates of violence and aggression in different geographical regions that vary in climate. Geographic region studies are designed to test and compare rates of violence and aggression in different latitudes that vary in climatic temperature. Research has shown that homicide rates are higher in southern regions of the US than other areas of the nation (Cohen & Nisbett, 1994). Anderson and Anderson (1998) report that geographic region studies have produced consistent findings, thus indicating that hotter geographical regions have higher rates of violence in comparison to colder regions. One of the earliest geographic region studies was performed by Lombroso (1911/1972) when he looked at the frequency of murder in northern states versus southern states in North America. He concluded that the southern states had hotter temperatures than the northern states and also had a higher number of murders. In addition, he found that southern England had a murder rate 10 times higher than observed in northern England (as cited by Anderson, 1989; Anderson & Anderson, 1998). Current geographic region

studies now include additional social and cultural variables as controls (Anderson & Anderson, 1996, 1998; Anderson et al., 2000; Van de Vliert et al., 1999) and the evidence derived from those studies and other parts of the world such as Pakistan and other hot cities (Simister & Van de Vliert, 2005) often points to an “affective aggression” model of temperature induced aggression (Anderson & Anderson, 1998, p. 270).

However, Anderson and Anderson (1998) note that “indirect effects” have not been ruled out in geographic studies. For example, Nisbett (1993) has suggested that a “culture of violence” exists due to a “culture of honor” (Cohen & Nisbett, 1994, p. 552) which may, in part, explain why certain geographical regions are plagued with higher rates of violence. Others have proposed a “*machismo* (macho) culture” (Simister & Cooper, 2005, p. 4) or “culture of violence” (Anderson, 1989, p. 14) to explain increases in aggression in hot regions. Van de Vliert et al. (1999) have studied cultural characteristics in different countries and have found evidence that masculinity may moderate the relationship between temperature and aggression. Furthermore, Van de Vliert (2007) has proposed that “climates create cultures” (p. 53) and further indicated that financial resources and capital mediate the influence that climate has on a culture. Boyanowsky (2007) contends that although research has produced evidence in support of such hypotheses, it is likely that they are only partial influences, and are likely just one part of a bigger picture. What is clear is that there is a need for additional research into the geographic effects of climate on rates of violence and aggression that takes into account factors identified by the other approaches as well. Specific theoretical approaches have been forwarded to account for the results documented in the above studies. However, before discussing those approaches, it is important to define aggression and violence for the purposes of this paper.

CHAPTER 2.

Differentiating between Violence and Aggression

2.1. Defining Aggression

It is imperative to point out that aggression is not an easily definable term, as it includes many forms of behaviour. According to contemporary theorizing, there are many different types of aggression. The definition of aggression will vary depending upon the prescribed circumstances, who is involved in assigning a definition and their specific interests for doing so. The definition of aggression here is restricted to the affective or reactive type, where an individual, or group of individuals, engage(s) in acts of aggressive violence against another person or persons in response to perceived immediate threat or instigation. That type of aggression is accompanied by a high degree of arousal resulting from some form of externally precipitated frustration, thwarting or attack and, as Berkowitz (1989) states, its “primary goal is to do harm” (p. 62). Such affective or reactive aggression is different from what is known as instrumental aggression that is used in a rational and calculated manner by an individual for the purpose of achieving a desired outcome in a particular situation (Berkowitz, 1989). Although those two categories may overlap in some respect, reactive aggression is less planned, more spontaneous and more often includes a strong emotional component associated with a heightened state of arousal. Ultimately, reactive aggression is primarily of importance to those scholars researching the heat aggression hypothesis that I shall describe presently.

2.2. Violence versus Aggression

Aggression is not the same as violence, although in many of the social sciences, according to Boyanowsky (1999), they have been used synonymously. For example,

Bartol and Bartol (2008) erroneously define reactive aggression as including “anger expressions, temper tantrums, and vengeful hostility, and more generally ‘hot-blooded’ aggressive acts” (p. 164). However, an act can be violent but not aggressive, aggressive but nonviolent, or both. Many studies have not defined violence and aggression prior to performing theoretical and statistical analyses, often erroneously confusing one type of phenomenon with another, ultimately leading to inconsistent conclusions. Boyanowsky identifies (1999, 2007) violence as any phenomenon involving the release of energy and/or the application of force that may or may not be aggressive. One example is a volcanic eruption, earthquake or storm. Giving birth is almost always violent and painful for both the child and mother as documented by many observers including Freud in his “birth trauma” (discussed in Hollitscher, 1947), but its intention is to produce life. At the other extreme, policy makers in the USA have been searching for a sure-fire method of execution that assures death without violence, for example, improving on lethal injection techniques. Another example is a child’s tantrum: throwing him/herself on the floor and screaming versus an attack that results in biting and kicking someone. The latter behaviour, unlike the former violent outburst, is aggression for there is intent to do harm to a person or thing. But aggression may not involve violence, for instance poisoning someone slowly and surreptitiously or spreading a vexatious rumour may involve little or no violence of action or reaction but is intended to be harmful and often can be very injurious or even lethal. Most of the research on temperature-aggression concerns aggression exercised using violent means. The theoretical approaches that researchers have forwarded to explain violent aggression in heat will now be briefly discussed.

CHAPTER 3.

Theoretical Approaches

In general, the three main theoretical approaches utilized in research undertaken to explain the temperature-aggression relationship include: the *heat hypothesis* (also referred to as the *temperature-aggression hypothesis*; Anderson 2001; Anderson et al., 2000; Anderson, Bushman, & Groom, 1997; Hipp, Bauer, Curran, & Bollen, 2004; Simister & Cooper, 2005; Wilhelm, 2003), *routine activities theory* (Ceccato, 2005; Cohn & Rotton, 1997; Field, 1992; Hipp et al., 2004; Rotton & Cohn, 1999, 2000a, 2000b, 2001, 2003), and *negative affect escape (NAE)* (Baron & Bell, 1976; Bell, 1992; Bell & Baron, 1976; Cohn & Rotton, 1997; Palamarek & Rule, 1979; Rotton & Cohn, 2000a, 2000b).

Different conclusions have been drawn from the different theoretical approaches used to research the relationship between temperature and violent aggression. Debates in this area of study often arise when scholars allow only one methodology or theoretical approach to dominate the design of their research, and that has often been the case. Rotton (1986) had previously claimed that “research on climate and behavior has been hampered by single-factor explanations, which earlier led investigators to ignore cultural factors and now lead them to deny environmental factors” (p. 346). However, current research has increasingly included such cultural influences (Simister & Van de Vliert, 2005; Anderson et al., 2000), overcoming many of the methodological problems inherent in the early studies. Each theoretical approach will be briefly discussed to show the theoretical positions within the temperature-aggression research.

3.1. Heat Hypothesis

According to Anderson (2001), “the heat hypothesis states that hot temperatures increase aggressive motivation and (under some conditions) aggressive behavior” (p. 33). That notion is consistent with evidence showing that heat primes aggressive thoughts (Rule, Taylor, & Dobbs, 1987), and the claim that there is a relationship between heat and aggressive behaviour (Harries & Stadler, 1983). Anderson (2001) indicates that there are social and situational factors that mediate whether or not heat stressed individuals will aggress or not, although the exact conditions have not been precisely determined.

The heat-hypothesis has been shown through various approaches and research findings from such studies have linked the effects of temperature on pitchers who hit batters in major league baseball games (Reifman, Larrick, & Fein, 1991), on intimate partner violence (Michael & Zumppe, 1983a), on aggressive driving (Kenrick & MacFarlane, 1986), aggression among police officers (Vrij, Van Der Steen, & Koppelaar, 1994), and on rule-breaking infractions in prisons (Dexter, 1989; Haertzen, Buxton, Covi, & Richards, 1993). Other related studies of the heat hypothesis have found a relationship between temperature and the severity of mental health symptoms among patients with bipolar depression (Shapira, Shiloh, Potchter, Hermesh, Popper, & Weizman, 2004) and schizophrenia (Shiloh, Munitz, Stryjer, & Weizman, 2007). Further, in line with Kropotkin’s early propositions, humidity in addition to temperature is known to increase physical distress (Rohles, 1974). Semenza et al. (1996) have noted that humidity influences the “evaporative and radiant transfer of heat between a typical human and the environment” (p. 85) and “is a better measure of the effect of heat on the body than temperature alone” (Semenza et al. 1999, p. 270), indicating that increased humidity can also serve to increase the mortality rate during heat waves. A number of researchers have included humidity (Auliciems & DiBartolo, 1995; Boyanowsky, 1999, 2007; Boyanowsky et al., 1972; Boyanowsky, Calvert-Boyanowsky, Young, & Brideau, 1981; Cohn & Rotton, 1997, 2000a, 2000b; Cotton, 1986; Ganjavi, Schell, Cachon, 1985; Harries & Stadler, 1983; LeBeau, 1994; Rotton & Frey, 1985) and precipitation (DeFronzo, 1984; Feldman & Jarmon, 1979; Perry & Simpson, 1987; Simister & Van de

Vliert, 2005) as additional explanatory variables when examining the relationship between temperature and violent crime.

To better understand the heat hypothesis Anderson and colleagues (2000) have applied the General Affective Aggression Model (GAAM); a micro-level theoretical construct that approaches temperature-aggression through the 'person in the situation', called an 'episode' (p. 79). Using GAAM, Anderson et al. incorporate temperature as a latent variable in a larger theoretical construct built to understand affective aggression. Their framework consists of 4 main components: "(a) inputs of various person and situational variables, (b) routes through which these variables have their impact, (c) appraisal processes, and (d) behavioral outcomes of the underlying appraisal processes" (pp. 79-80).¹ The inputs and various routes outlined in the model are dynamic in facilitating aggressive drives and one can enter the model at various points.

The model's inclusion of "personological variables" (p. 79) is important because most research on temperature-aggression, with the exception of Boyanowsky's (1999; 2007) Ecs-TC Syndrome (to be discussed later in detail) has ignored person-specific psychological and developmental factors. Anderson et al. (2000) note that such "person factors include all the specific things that a person brings to the situation, such as personality traits and attitudes" (p. 80) and further contends that at a psychological level, normally inconsequential events are inflated by a heat-stressed individual, often resulting in a progressive cycle of aggressive retaliation. More pointedly Anderson (2001) explicates how social interaction and psychological processes account for aggression in heat:

I believe that most heat-induced increases in aggression, including the most violent behaviors, result from distortion of the social interaction process in a hostile direction. Heat-induced discomfort makes people cranky. It increases hostile affect (e.g., feelings of anger), which in turn primes aggressive thoughts, attitudes, preparatory behaviors (e.g., fist clenching), and behavioral scripts (such as "retaliation"scripts). A minor provocation can quickly escalate, especially if both participants are affectively and cognitively primed for hostility by their heightened level of discomfort. A mild insult is more likely to provoke a severe insult in response when people are hot than when they are more comfortable.

¹ See Appendix A for GAAM as depicted in Anderson et al., 2000, p. 79.

This may lead to further increases in the aggressiveness of responses and counter responses. (p. 36)

Anderson et al. (2000) illustrate how negative affect due to situational variables such as uncomfortable temperature and provocation can influence cognitions and arousal. For example, if an individual, particularly one with an aggressive personality or a tendency for hostile attribution bias, is in a temperature-induced cognitive and physiological state of emotional and cognitive stress, and is provoked, they are more likely to perceive a situation as being threatening and violent aggression can ensue.

It should be noted that the influence of temperature on aggression is very dynamic and dependent upon many factors. Anderson et al.'s (2000) inclusion of person-specific variables is important in explaining why one may aggress in heat since uncomfortable temperature may only serve as a risk factor for violence in some people and only in certain situations. For example, one individual may respond aggressively in a given situation by verbally attacking someone, while another may instead use physical violence as that has been a successful measure in the past, whereas still another may not personify or misattribute their discomfort at all, perhaps reflecting that they are aware that they are getting hot and bothered and in response decide to take it easy or 'chill out'. Developmental factors over one's life course likely determine such outcomes which is something that current research has not tested, only constructed. The difficulty in including those factors in current research prevents theories on temperature-aggression from gaining more support among criminologists and the academic community in general. On the other hand, Cohn (1990) has indicated that temperature is often ignored in criminological research: "in studying crime most criminologists have concentrated on traditional socio-demographic variables, such as age, sex, race, and socio-economic status" (p. 51). Boyanowsky (2007) emphasizes that there is a need for future research on the heat hypothesis to address the underlying causes of violent aggression and to consider the influence of biology and social factors, not simply one or the other as some researchers have done. He asserts that the heat hypothesis is not a complete model for understanding temperature-aggression. In fact, Boyanowsky has also pointed to evidence produced elsewhere that suggests that climate can affect the development of some social variables and cultural customs, that may in turn influence the way that people adapt and respond to heat in different geographical locals and how cold may

produce reactions that although at first blush may appear similar to those triggered in heat, involve different emotions, motivations and outcomes. Still, other scholars have examined the temperature-aggression relationship from the different, but not necessarily incompatible perspective of routine activities theory.

3.2. Routine Activities Theory

Time period studies have produced some evidence for routine activities theory in explaining increases in violent aggression during warmer temperatures. In its most basic form, routine activity theory comprises three elements that must simultaneously converge in time and space in order for a crime, notably a crime of a predatory nature, to occur: (a) *motivated offenders*, (b) *suitable targets*, and (c) the *absence of capable guardians against a violation* (Cohen & Felson, 1979, p. 589).

It has been proposed that when the environmental temperature warms to more comfortable levels people are more likely to leave indoor settings and other socially isolated dwellings to go outdoors to spend more of their leisure time (Baron & Ransberger, 1978). That response serves to increase the frequency of contact between potential victims and potentially motivated perpetrators in those settings (Cohn & Rotton, 2000b). In addition, it has been purported that people consume more alcoholic beverages during warmer periods of the year (Anderson et al., 1997; Cohn, 1990; Cohn & Rotton, 1997; Cheatwood, 1988; Harries & Stadler, 1988; Harries, Stadler, & Zdorkowski, 1984) possibly accounting for some of the effects of heat as alcohol has been shown to be a major precursor and/or disinhibitor of aggression (Bushman & Cooper, 1990), contributing to increases in violent crime rates during warmer periods of time.

However, for purposes of scientific analysis, it is important to distinguish the “heat effect” from the “heat hypothesis”. According to Anderson and Anderson (1996), “the *heat effect* is the observation that aggression rates are often positively associated with warmer temperatures and the *heat hypothesis* is the theoretical conception that uncomfortably warmer temperatures produce increases in aggressive motives (sometimes) resulting in aggressive behavior” (p. 740). The former is considered an ‘indirect effect’ and the latter a ‘direct effect’ on violent aggression (Anderson &

Anderson, 1998). In their statistical analysis, Anderson and Anderson (1996) make a strong case for heat playing a major psychological or affective role in accounting for violent crime rates. Their analysis does not, however, discount the effects of routine activity or the effects of alcohol consumption, but rather that several approaches may be complementary, specifically that heat causes negative affect and brings more people into contact with one another, and sometimes those people are also intoxicated. Still, the exact situational variables involved in initiating aggression in heat have not been precisely determined, and some scholars have put forth the negative affect escape theory to help account for conflicting findings.

3.3. Negative Affect Escape

According to Anderson and Anderson (1998) “negative affect escape theory [NAE] focuses on the current state of the individual and their (sic) behavioral motives” (p. 257). Research has shown that negative affect increases as a function of temperature (Anderson, Anderson, & Deuser, 1996; Baron, 1979; Boyanowsky, 1999), and as negative affect increases so does motivation for aggression (Anderson & DeNeve, 1992). Anderson and DeNeve further assert that motivation to escape the stressful situation increases as negative affect increases. Furthermore, they indicate that the behaviour in which one chooses to engage while experiencing negative affect depends on many factors, such as prior emotional state, the characteristics of the situation, the level of temperature and individual conditioned responses to stress. Those advocating or providing evidence for the NAE model argue that hot or cold temperatures can initiate or prime the potential for aggression up to a certain point and then the effect levels off when temperatures become too uncomfortable (too hot or too cold) for an exposed individual to tolerate, whereupon their priority will be to escape the situation (Bell, 1992; Bell & Baron, 1976; Cohn & Rotton, 1997; Palamarek & Rule, 1979). If an individual who is experiencing negative affect due to very extreme temperatures has the ability or option to escape that particular situation, he may choose to flee those uncomfortable conditions. However, if they cannot remove themselves from the situation then aggression, sometimes violent aggression will ensue (Anderson & Anderson, 1998).

Evidence obtained for negative affect escape theory from time period and geographic studies lacks practical substance, and further, such studies have produced inconsistent results (Bell, 1992). Nevertheless, Anderson and DeNeve (1992) “agree that the negative affect escape model warrants additional empirical investigation” (p. 347). Closer scrutiny reveals that many of those inconsistencies arise from the different methodologies employed in studying the issue (i.e., time period studies vs. geographic region studies vs. laboratory/concomitant studies). Anderson and DeNeve further assert that NAE has yet to be confirmed or rejected through time period or geographic region studies, and that there is a pressing need for more carefully designed laboratory studies in order to address the issue.

3.4. Psychophysiology

In addition to correlational approaches and the social theoretical propositions for temperature-aggression, inevitably there are physiological factors underlying the temperature-aggression relationship. Various psychophysiological mechanisms have been suggested in previous works pertaining to individuals at the individual level that may possibly account for the temperature-aggression findings (Anderson, 1989; Boyanowsky, 1999, 2007; Michael & Zumpe, 1983a; Simister & Cooper, 2005; Tihonen, Räsänen, & Hakko, 1997; Wilhelm, 2003). Anderson and Anderson (1998) indicate that “biological theoretical explanations can be seen as complementing higher level theories by suggesting the physiological mechanisms directly responsible for heat effects on emotions” (p. 254). In one study conducted by Boyanowsky (1998) he found that subjects experiencing anger reported similar uncomfortable physical symptoms as individuals exposed to uncomfortable temperatures. Anderson and Anderson indicate that the exact physiological mechanisms for thermoregulation facilitating aggression in heat have yet to be determined. However, research has confirmed that high temperatures disrupt the body’s ability to maintain homeostasis in regards to core temperature and the resulting physiological thermoregulatory response causes increases in heart-rate, blood flow, respiration, and sweating (Angilletta, 2009; Bazett, 1927; Heins, 1983). Therefore, if an individual who is heat stressed is provoked when they are already experiencing a heightened state of physiological arousal they may be more likely to perceive a relatively minor insult as a major one, especially because an

insult or provocation can further increase physiological arousal. Furthermore, it has been noted that following exposure to extreme heat the body shunts blood to peripheral areas in the body in an attempt to cool the body, however this also results in a decrease in blood flow to the brain (Heins, 1983), which may account for reduced discriminatory powers observed in individuals aggressing in some laboratory studies. In addition, humidity affects the body's physiological ability to dissipate heat (Heins, 1983) which may explain why an exact temperature threshold for aggressing in heat has not been precisely determined and may account for some of the inconsistent findings in time period studies that have neglected to consider humidity in statistical analyses (T. Takaro, personal communication, April 10, 2010). This is an important area of focus for future studies on temperature-aggression.

3.5. Criticisms of Current Approaches

3.5.1. *Time Period Studies*

It has been argued that seasonal fluctuations may cause problems in interpreting the results from some time period studies (Anderson et al., 2000). For example, increased temperatures may simply result in changes in school, employment, vacation and other regular everyday activities that may also lead to increased potential for aggression (Anderson et al., 1997). More generally, Anderson and colleagues (2000) mention that some scholars have asserted that people cannot clearly interpret a provocation in their immediate environment (i.e., given the effects of heat-induced attention deficits) when experiencing heat stress, an effect essentially mediating potential possibilities for social conflict. High levels of affective arousal could serve to detract from a person's ability (i.e., cognitively) to pay attention to stimuli in the surrounding environment and therefore an individual may not have the mental ability to perceive that an external conflict or threat is occurring. Anderson et al. (1997) also explain that 'social justice' can explain away the heat-aggression hypothesis, in that when individuals feel that they have sufficiently punished the person that they are directing their anger towards (e.g., giving someone the finger at an intersection) they will perceive that person as an instigator who has received social justice and thus has been sufficiently punished. The latter two problems are not peculiar to time period studies

alone, but rather have implications for all studies. For a more complete discussion of the potential problems with time period studies refer to Anderson et al. (1997).

3.5.2. Laboratory Studies

There are some inherent problems with the methodology used in studying the relationship between temperature and aggression in laboratory/concomitant settings. Researchers have stipulated that some of the conclusions in those experiments could be peculiar to laboratory setting because aggression in the lab is fundamentally different from “real” aggression, and therefore findings from such studies may lack “external validity” (Anderson et al., 1997, p. 1214). However, concomitant research conducted in naturalistic settings, such as Kenrick and Macfarlane’s (1986) driver aggression study has disputed those alleged shortcomings.

Another potential drawback of laboratory studies is that the option to escape rather than aggress in those settings is not always available (Anderson et al., 2000). Boyanowsky (1999) points out that in some of those laboratory experiments a fatal error involved informing the participants that researchers were studying the influence of heat on performance, thus possibly destroying the validity of the subsequent results. Specifically, he asserted that “those subjects tested were informed of the purpose of the experiment and attributed their physiological arousal and psychological distress to the ambient temperature, resulting in a reduction of their emotional arousal” (Boyanowsky, 1999, p. 268). That proposition indicates that if a person is consciously aware that their negative state of affect is due to uncomfortable heat then it is less likely that they will misattribute or personify their negative affect as being caused by an individual, usually acting as a provocateur, in their surrounding environment.

Regardless of the above criticisms, the high number of replicated findings from laboratory and concomitant studies attests to the existence of a relationship between temperature and aggression. That conclusion is further supported when triangulated with evidence from geographic and time period studies. Boyanowsky’s (1999) studies have the further validity of relating the outcome—instrumental aggression and violent aggression to precursor and triggering cognitive, affective and physiological states.

3.5.3. Geographic Region Studies

Lastly, some researchers disagree on the interpretation of results from geographic region studies. Anderson et al. (1997) state that “different regions typically vary on a number of dimensions other than temperature, dimensions that might be related to aggression” (p. 1214). Some have proposed that differences in violent crime rates between different regions can be explained away by historical and cultural effects (Nisbett, 1993). For example, as previously mentioned Cohen and Nisbett (1994) claimed that a southern “culture of honor” (p. 552), referred by some as a “southern culture of violence” (SCV; Anderson & Anderson, 1998, p. 256) developed in the lower half of the United States and can be traced back to colonial days when geographic isolation combined with a lack of law enforcement, forced southerners to take measures into their own hands for self preservation, such as defending their means of subsistence (i.e., property and livestock). That may explain, in part, the differences in violent crime rates in the southern states relative to the northern states. However, Anderson and Anderson note that SCV theories have not gained considerable empirical support, but do acknowledge that the heat hypothesis and SCV are not incompatible and may very well both be impacting violent crime rates independently of each other. For a more detailed discussion of the SCV and its place in evolutionary psychology see Nisbett (1990, 1993) and Cohen and Nisbett (1994, 1996).

3.6. Linear versus Curvilinear Debate

In addition to the criticisms of current research, there is disagreement among scholars on the exact shape of the relationship between temperature and violent aggression. Some argue that the relationship is monotonic (Anderson & Anderson, 1984, 1998; Boyanowsky, 1999, 2007; Boyanowsky et al., 1981; Bushman, Wang, & Anderson, 2005b; Harries & Stadler, 1988; Reifman et al., 1991), while others contend that it is rather curvilinear in nature—violent aggression is linearly related to temperature until a certain point where it levels off and declines as the temperature increases (Baron & Bell, 1976; Baron & Ransberger, 1978; Bell & Baron, 1976; Rotton & Cohn, 2000a). Currently there is no strong evidence pointing to an exact threshold for this effect,

although it is likely to be at very high temperature ranges perhaps approaching states of exhaustion (Boyanowsky, 1999).

There have been many studies conducted to address the linear versus curvilinear issue. Cohn and Rotton (1997) discovered that the number of assaults committed over two years in Minneapolis, Minnesota increased as a function of temperature. The number of assaults peaked at approximately 75°F, and then decreased. However, using the same data, Bushman et al. (2005a, 2005b) argued that assaults actually continued to increase linearly when analyzed during points of the day in which crime typically occurs (9:00pm-3:00am). A more recent study conducted by Cohn and Rotton (2003) demonstrated that both the number of assaults throughout the United States, and by state, were significantly correlated with area-averaged annual temperatures in the US over 50- and 39-year-periods suggesting that as temperatures continued to increase on an annual basis so did violent criminal activity.

Still other researchers such as Baron and Ransberger (1978) have reported a curvilinear relationship between ambient temperature and the incidence of rioting. The results from that study led them to acknowledge that moderate temperatures contribute to increases in mass violence, but they contrarily documented a decrease in such incidents when temperatures soared above 85°F. However, those findings have been criticized by other researchers. Carlsmith and Anderson (1979) have claimed that experimental errors occurred in Baron and Ransberger's field study, specifically in the analysis of their data. Anderson and Anderson (1984) reaffirmed that contention in a follow-up study, wherein they observed a statistically significant linear relationship between temperature and crime, particularly violent crime. As demonstrated, the varying findings reported from those studies continue to fuel debate in the temperature-aggression literature. Even though considerable debate surrounds the issue of whether it is linear or curvilinear (see Cohn & Rotton, 2005), a strong consensus remains that as temperature increases so does negative affect, and often violently aggressive criminal behaviour.

It is important to acknowledge temporal-spatial factors when applying routine activities theory to temperature-aggression as it may explain conflicting or disputed findings. While research in most laboratory settings has clearly depicted a linear

relationship, social changes involved with warmer weather may explain why this relationship sometimes appears curvilinear. For example, one study found that there was a drop in violent crime during the hottest time of the day (Cohn & Rotton, 1997), however they did not take into account the fact that temperature peaks around four to six pm, the time of the day that a large proportion of the population are in their cars, limiting opportunities for potential perpetrators and victims (Boyanowsky, 2007). Further, some researchers argue that curvilinear relationships can be understood by combining NAE with RAT to show that increases in temperature above human comfort levels cause people to seek refuge in indoor climate controlled settings when practically available (Rotton & Cohn, 2004). In review, Boyanowsky (1999) has indicated that methodological differences may explain mixed findings in the field.

The effect that temperature has on precipitating violence and the shape of that relation depends on the geographical location, time of the day, day of the week, and the month. Anderson et al. (2000) observed that when temporal variables are controlled, a positive and linear relationship between temperature and assault emerges, which may be an indication that integrating opposing theories is beneficial. Field (1992) agreed that “it is entirely possible that temperature affects the level of crime both through a direct effect on aggression and through the mediation of social behavior” (p. 348). Therefore, considering all relevant theories may overcome some of the shortcomings of previous research. There remains a need to conduct more research in this area of temperature-aggression to determine under what conditions the relationship is monotonic versus curvilinear.

3.7. Integrating Perspectives

Theoretical integration may lead to a better understanding of the association between temperature and the incidence of violent aggression. In fact, some scholars warn of the problematic nature “of championing one theory to the exclusion of all other models and theories” (Cohn & Rotton, 2000a, pp. 688-689). It has also been argued that the common practice of “theory perseverance might dissuade other scholars from pursuing an interesting and potentially applicable line of research” in relation to temperature-aggression (Rotton & Cohn, 1999, p. 619). Moreover, it is said temperature

may influence human behaviour directly or indirectly (e.g., negative affect or social routines/contact) (Anderson & Anderson, 1998; Rotton, 1986; Rotton & Cohn, 2000b) and that several theories should be considered (Cohn & Rotton, 1997). For example, scholars of routine activities theory focus more on the wider physical environment and its interaction with temperature (or seasonally) related social routines, whereas those that favor the heat aggression hypothesis focus more on individual and social-psychological explanations for understanding/explaining crime, including the importance of individual and group dynamics. In the case of temperature-aggression in general, routine activities theory may help explain increases in violent aggression in warmer weather. For example, as previously mentioned, pleasant weather serves to bring more people outdoors increasing the likelihood of contact between different types of individuals (Cohn & Rotton, 2000b). That effect, however, should suggest a higher incidence of aggressive behaviour in the springtime, especially in cities that have suffered very cold winters. Increases may be observed at drinking establishments as well, bringing more people with aggressive tendencies into contact with other aggressive individuals. Alcohol serves to reduce the threshold for violent aggression (Boyanowsky, 2007; Taylor & Gammon, 1975; Taylor, Schmutte, Leonard, & Cranston, 1979), impairs judgement (Dunlop, n.d.) and gives rise to violent and aggressive altercations (Bushman & Cooper, 1990). More pointedly, routine activity theory is compatible with the heat aggression hypothesis because if temperature brings more people together (crowding urban areas), and individuals in these environments are primed for aggression, then a cumulative dynamic should be expected. However, advocates of heat aggression hypothesis have yet to empirically determine if certain types of individuals are more susceptible to aggressing during periods of high temperature.

Hipp and colleagues (2004) tested the utility of routine activities theory (RAT) and the heat aggression hypothesis (HAH) in accounting for variations in both property and violent crime. They found support for both RAT and HAH. More specifically, they indicated that both theories received 'predictive' support. RAT was more successful in predicting variations in crime rates in geographic locales experiencing "moderate-temperatures" (p. 1357), while HAH (they refer to as *temperature/aggression*) had more predictive power in locations that experienced hot summers. However, it should be noted that they did not consider the fact that humans acclimatize differently to ambient

temperatures at different latitudes (Takaro, personal communication, April 10, 2010). On the other hand, property crime was also influenced by seasonal variations in weather and reportedly increased as a function of ambient temperature. However, the authors caution that there are many other factors at play in explaining such variations, and that the physical environment shapes how different crimes manifest in a city. For instance, they assert that “entertainment establishments have a positive effect on both overall levels of crime and seasonal oscillations in crime” (p. 1359). Lastly, the authors note that while demographic factors explain ‘how much’ crime occurs during the year, weather factors influence ‘when’ it happens, while also stating “individuals respond to their environment—either social or physical—in ways that can give rise to such emergent effects” (p. 1365).

As highlighted, the main theoretical approaches to explaining temperature-aggression have commonly been applied in isolation, but show promise when considered together. Combining those paradigms may provide greater explanatory power in understanding increases in violent aggression during times of high temperature. Although there are some inconsistencies in the research, one scholar has formulated an over-arching and more comprehensive model for explaining temperature-aggression.

3.7.1. *Ecs-TC Syndrome*

Boyanowsky (1999) conducted considerable research on the influence of temperature on human behaviour. He presented a series of studies on temperature-aggression and proposed a psychophysiological-based conceptual model, the *Ecs-TC syndrome*: “emotions, cognitions, and stress caused by affective-thermoregulatory conflict” (p. 268) to explain violent aggression in heat. He asserts that “these effects upon the individual—arousal, growing irritation, thermoregulatory conflict, and a narrowing of cognitive focus on the source of this distress—contribute to an understanding of the causes of collective violence during heat waves” (p. 268). In that regard Boyanowsky (2007) points to propositions made by some researchers that there is a release of neurohormones and neurochemicals by the anterior hypothalamus during thermoregulation. He also contends that when there are “systemic conflicts operating,

such as attempts at thermoregulation by individuals suffering from heat stress while being provoked, acts of retaliation are exacerbated by misattribution of the stress to the human source of provocation” (p. 262).

Boyanowsky (1999) found that subjects exposed to high temperatures in the laboratory showed rising core temperatures that were accompanied by increased reported anger and hostility, increased heart-rate and increasingly inappropriate aggression against an antagonist (measured by duration and intensity of shock purportedly delivered—in actuality only a reading on the experimenter’s panel). No comparable effect was obtained in cold temperatures although based on the reported affect of subjects, “aggression aroused in heat appears to be more emotional in nature than retaliatory aggression in cold” (p. 270). Additionally, the pattern of aggression in cold had a lower “response latency” (p. 265) that occurred faster in response to an attack than aggression in heat and was more specifically appropriate to the behaviour of the antagonist and accompanied by less emotion. When subjects were made aware of the ambient temperature in heat, core temperature, heart-rate, anger, response latency and intensity of aggression were reduced but all responses in cold remained at heightened levels. Boyanowsky proffers that “attention, cognition, and negative affect mediate aggression in heat but not in cold” (p. 266) and that aggression in cold temperatures is more instrumental or goal driven in nature. In that sense, the Ecs-TC syndrome may help account for the spikes in violent assault observed during the colder months in Yasayko’s (2007) study (see Figures 1-3). Moreover, in previous research conducted by Boyanowsky (1977) he observed that decreasing temperatures were related to increases in sexual arousal measured by preference for sexual material and self report, a notion supported by current research being conducted by Boyanowsky and Yasayko (2010) showing that conception rates in both animals and in humans tend to increase during the seasonal transition to colder temperatures.

To reiterate, perhaps the most important finding from Boyanowsky’s (1999) research was that when subjects were made cognizant of the ambient temperature, prompted by a large thermometer situated on their control panel, they showed a reduction in tympanic temperature, heart-rate, hostility and aggression, the unchanged ambient temperature, notwithstanding. Boyanowsky indicated that an awareness of the heightened temperature and associating it with the distress eliminated Ecs-TC, and

thermoregulation was restored. Therefore if people are aware that they are experiencing negative affect due to heat they are less likely to personify or misattribute their discomfort to another source.

Consistent with Boyanowsky's (1999) proposition that having an awareness of heightened temperature can serve to mitigate aggression, Berkowitz, Schragar, and Dunand (2006) found that aggression resulting from uncomfortable heat can be prevented from escalating if those affected perceptually implicate a direct noninstrumental/nonconflictory source to be responsible for their negative emotions. The participants were assigned two at a time in heated rooms to determine if social interaction without the possibility of escape could influence the likelihood of a particular individual's becoming aggressive in those conditions. The findings showed that "the highest level of aggression was displayed by the participants in the hot room working with a partner whose emotional reactions were different from their own" (p. 80). The researchers further indicated that the participants' "counterparts, also exposed to the high temperature but whose partner's feelings were similar to their own, exhibited the least aggression" (p. 80). That conclusion corresponds with Boyanowsky's (1999) argument that being consciously aware of the source (heat) of negative stimuli allows an individual to associate that source with their uncomfortable feelings, preventing a person from having to look for the next possible (but less likely) source of their discomfort.

On the whole, Boyanowsky's (1999) Ecs-TC Syndrome takes into account differences in aggression reported in hot and cold climates, and integrates various theoretical levels of understanding better to explain why people aggress in heat. Following a review of geographic region studies, Boyanowsky hypothesized that possibly:

humankind has not evolved separately in adaptation to hot versus cold climates, and so people in hot climates may often be functioning in a state of mild to severe thermoregulatory stress that lowers their threshold for violent reactions to instigations such as insults, perceived or real, that create thermoregulatory conflict. (p. 269)

That proposition suggests that those living in the hottest regions are the most at risk for becoming violently aggressive due to ubiquitous thermoregulatory conflict. In areas with hot environmental temperatures he suggests that "such cultures would, out of

necessity, have much more elaborate interaction scripts for governing politeness and more formal rituals for settling matters of honor” (Boyanowsky, 1999, p. 269). The Ecs-TC syndrome helps explain conflicting findings from the heat hypothesis, routine activities theory, and negative affect escape theory, while shedding light on the potential ramifications temperature has on the development of culture and social interaction in different geographical regions.

CHAPTER 4.

The Present Study: Aggression as a Function of Ambient Temperature

As demonstrated, the Ecs-TC Syndrome takes into account various levels of understanding to explain violent aggression related to heat. The present study expands on past research on temperature and violent crime in Canadian cities conducted by Yasayko (2007) and will use Boyanowsky's (1999) Ecs-TC Syndrome as a template for exploring the attacks on transit drivers as a result of aggression as a function ambient temperature, or "emotional-cognitive stress induced by thermoregulatory conflict" (Boyanowsky, 2007, p. 6).

As discussed, to date little research on temperature-aggression has differentiated between incidents that are violent and those more suitably defined as reactively aggressive in nature (e.g., robbery vs. aggravated assault). Specifically, the study will use Boyanowsky's (1999, 2007) conception of affective aggression to differentiate between aggressive and non-aggressive incidents against transit drivers. However, such classifications are exploratory and violence and aggression lie on a continuum that increases the risk for misclassification. Such classifications may not yield any significant findings, therefore both 'nonaggressive' and 'aggressive' incidents will for comparison purposes, also be combined into a single composite in keeping with previous time period studies examining temperature and crime. The Ecs-TC Syndrome will then be used to interpret the results, and by applying the Ecs-TC Syndrome to the current literature on the heat aggression hypothesis additional empirical support can be generated to help clarify this area of the temperature-aggression phenomenon.

4.1. Research Questions and Hypotheses

As previously mentioned, the present study investigates the influence of environmental temperature on the rate of aggressive and nonaggressive violent incidents against bus drivers. Although past research has not differentiated among violent crimes based on psychological intent, the current analysis will do so in line with Boyanowsky's (1999, 2007) definition of aggression where the primary intent of the perpetrator is to inflict direct physical harm upon the victim. Similar to previous time period studies, the current study investigates temperature and violent crime over three different periods of time (seasons, months, and weeks), but also controls for the opportunity for contact between perpetrators and victims (ridership). More specifically, the goal of this research is to determine: (a) are there significantly more incidents of aggressive violence versus nonaggressive violence against transit drivers in Metro Vancouver during warmer seasons than colder seasons based on Boyanowsky's classifications?; (b) Is there a significant relationship between higher monthly environmental temperatures and the manifestation of aggressive violence versus nonaggressive violence against transit drivers in Metro Vancouver based on Boyanowsky's classifications?; (c) Is there a significant relationship between higher weekly environmental temperatures and the manifestation of aggressive violence versus nonaggressive violence against transit drivers in Metro Vancouver based on Boyanowsky's classifications?; and (d) Is there a positive and significant relationship between the number of passengers and the number of attacks against transit drivers?

4.1.1. *Warmer Seasons and Aggression*

Hypothesis 1. There are significantly more aggressive, but not nonaggressive violent incidents against transit drivers in Metro Vancouver during warmer seasons than colder seasons.

Previous research has highlighted that warmer seasons are often associated with increased rates of violent crime (Anderson, 1987, 1989; Ceccato, 2005; Chang, 1972, Falk, 1952; Field, 1992; Haertzen et al., 1993; Harries et al., 1984; Hipp et al., 2004; Leffingwell, 1892; Lewis & Alford, 1975; Lombrosso, 1899, 1911; Michael & Zumpe, 1983a, 1983b; Perry & Simpson, 1987; Pettigrew, 1985; Rotton & Frey, 1985; Simister &

Cooper, 2005; Tennenbaum & Fink, 1994; Tihonen et al., 1997). Most research has not differentiated between crimes of violence from those that are violent and nonaggressive and those that are violent and aggressive. For example, some temperature-aggression time period studies have included robbery (Anderson, 1987; Anderson & Anderson, 1984; Anderson et al., 1997; Cotton, 1986; Perry & Simpson, 1987; Rotton & Cohn, 2003, 2004), disorderly conduct (Rotton & Cohn, 2000b), and even kidnapping (Cohn & Rotton, 1997) in their violent crime composites. However, robbery is more often associated with instrumental aggression, which is not the same as reactive aggression where there is intent to harm. One study that examined robbery observed increases during the winter months, which was explained by routine activities theory (Landau & Fridman, 1993), therefore it should not be included in violent crime composites measuring temperature and aggression. Furthermore, kidnapping and disorderly conduct are not considered to be crimes of reactive aggression. It is hypothesized that aggressive incidents against transit drivers will increase significantly during warmer seasons, but not nonaggressive incidents as based on Boyanowsky's (1999) conceptualization of violence and aggression.

With the exception of a few studies (Kenrick & Macfarlane, 1986; Michael & Zumpe, 1986; Reifman et al., 1991) most research conducted outside laboratory settings has not controlled for potential confounding variables that may influence the likelihood of victims and perpetrators coming into contact with one another. It is important to include such controls or else the findings observed in such studies can easily be explained away through the lens of routine activities theory. Therefore, the present study will control for the number of passengers coming into contact with transit drivers in order to control for changes in ridership that could account for increased numbers of incidents against transit drivers during warmer months.

4.1.2. Warmer Months and Aggression

Hypothesis 2. There is a positive and significant relationship between temperature and incidents of violent aggression, but not incidents of nonaggressive violence against transit drivers in Metro Vancouver during warmer months of the year.

A large number of studies have found a link between month of the year and the frequency of violence and have reported higher incidents during warmer months compared to colder ones (see Anderson, 1989, for a comprehensive review). Moreover, monthly time period studies have also compared monthly temperature to violent crime rates (Cotton, 1986; Dexter, 1899; Ganjavi, Schell, & Cachon, 1985; Linkowski, Martin, & DeMaertelaer, 1992, Perry & Simpson, 1987; Pettigrew, 1985; Simister & Cooper, 2005; Simister & Van de Vliert, 2005) however, the motives behind those predatory crimes have not been assessed. For example, similar to the first hypothesis, crimes of instrumental aggression such as robbery may involve the application of violence, but generally only enough force necessary to accomplish the act is exercised, whereas crimes of reactive violent aggression include the intent to directly harm the victim as the primary goal. Relying on Boyanowsky's (1999) conception of violence and aggression, acts of aggressive violence against transit drivers are hypothesized to be significantly related to monthly temperature, but that increase is not expected to be observed for incidents of nonaggressive violence, although some research has shown that instrumentally aggressive violence increases as temperatures drop (Boyanowsky et al., 1981; DeFronzo, 1984; Landau & Fridman, 1993).

4.1.3. Warmer Weeks and Aggression

Hypothesis 3. There is a positive and significant relationship between temperature and incidents of violent aggression, but not incidents of nonaggressive violence against transit drivers in Metro Vancouver during warmer weeks of the year.

Similar to Hypothesis 2, it is hypothesized that hotter temperatures will be significantly related to increased incidents of aggressive violence, but not nonaggressive violence against transit drivers during warmer weeks (as based on Boyanowsky's 1999 conceptions). Very few studies have tested temperature-aggression over weekly time

periods. The benefit of testing during warmer weeks than in comparison to warmer seasons or months is that weekly analyses are more direct measures of temperature and aggression. In addition, such comparisons allow for the inclusion of humidity as well as temperature into an 'effective temperature' or heat index based composite that more accurately represents heat hazard.

4.1.4. Number of Passengers and Attacks against Drivers

Hypothesis 4. There is a positive and significant relationship between the number of passengers and the number of attacks against transit drivers.

Finally, it is hypothesized that increases in the number of passengers will be positively related to increases in the number of attacks against drivers for all categories of violence. This proposition is consistent with previous research on temperature and violent crime that has used routine activities theory to highlight how changes in social routines can influence violent crime rates (Baron & Ransberger, 1978; Ceccato, 2005; Cohn & Rotton, 1997, 2000b; Field, 1992; Hipp et al., 2004; Rotton & Cohn, 1999, 2000a, 2000b, 2001, 2003).

CHAPTER 5.

Methodology

5.1. Variables

5.1.1. *Independent Variables: Climate Data*

Each hypothesis requires a different aggregation of variables to run specific analyses. The first hypothesis will be addressed by performing a 1-way ANOVA, therefore it is not necessary to create any independent variables to test that hypothesis. The next two hypotheses require the inclusion of explanatory variables to properly conduct the bivariate statistical analyses. The data used to create the explanatory variables for the second and third hypotheses (i.e., monthly and weekly comparisons) was obtained from Environment Canada's website. The three explanatory variables are temperature, effective temperature (temperature + humidity) and temperature² (temperature squared). Temperature² is a quadratic component that will be included in the monthly and weekly regression analyses to test for a possible curvilinear relationship between temperature and violent crime as used in similar field studies (Anderson & Anderson, 1984, 1998; Baron & Ransberger, 1978; Bell & Fusco, 1989; Cohn & Rotton, 1997, 2005; Cotton, 1986; Reifman et al., 1991; Rotton & Cohn, 2000a, 2001, 2003, 2004; Rotton & Frey, 1985). The variable was created based on Aiken and West's (1991) method of first centering the variable and then squaring it. Only the weekly analyses will be assessed using effective temperature as it is not theoretically sound to include humidity in monthly comparisons due to the wide range of variation of humidity over monthly time periods. In addition, monthly and weekly mean temperatures will be compared to the monthly and the weekly dependent composites. Finally, for the final hypothesis monthly ridership will be used as an explanatory variable to determine if increases in the number of passengers account for increases in attacks against drivers.

5.1.2. Dependent Variables: Attack Data

The dependent variables are derived from unpublished daily data consisting of aggressive and nonaggressive incidents against Coast Mountain bus drivers operating from January 2006 through December 2007 in Metro Vancouver, Canada. During that time period there were 470 attacks against transit drivers recorded by the transit company in six distinct categories: verbal threats (108), spat at (28), spat on (91), spat on face (57), physical assault (138), and assault with a weapon (48). Boyanowsky (personal communication, March, 19, 2008) contends that the first three categories: verbal threats, spat at, and spat on may be classified as expressive or violent (nonaggressive violence), since they involve the release of energy or force without any specific 'intent to harm' that Berkowitz (1989) agrees is necessary to classify an act as reactive aggression. There were a total of 227 attacks included in the nonaggressive violent composite. Further, Boyanowsky asserts that the latter three categories: spat on face, physical assault, and assault with a weapon are more appropriately classified as acts of aggression (violent aggression) since they involve physical contact and increasingly more intense, direct intent to harm. That composite comprises 243 total attacks. Finally, it is important to note that violence and aggression lie on a continuum from less serious to more serious, and it is likely that all six categories include some level of emotional/cognitive precursors of aggression, i.e., anger. Therefore the six categories will be combined to produce a composite (total violence) that encompasses all 470 attacks in order to address potential misclassification and to stay consistent with previous research. The purpose for creating the three composites was to test for a potential relationship between temperature and nonaggressive violence, aggressive violence and total violence since the former two are considered to be theoretically distinct terms. Finally, to further explore the data and to take into account potential misclassification of the composites, each type of attack for the seasonal and monthly analyses will be tested separately, with the exception of the weekly analyses as there are not enough attacks per year to aggregate in order to run statistical tests for those shorter time periods.

In addition to the data being grouped into 3 separate composite variables, each composite will be aggregated by seasons ($n=8$, 2 years x 4 seasons for 2006 and 2007),

months ($n=24$, 2 years x 12 months for 2006 and 2007), and weeks ($n=104$, 2 years x 52 weeks for 2006 and 2007) in order to address each of the three hypotheses. The first aggregation was created to determine if there is a relationship between season and incidents against bus drivers, while the latter two were developed to determine if temperature is related to nonaggressive and aggressive violent incidents against transit drivers during warmer months and weeks of the year.

5.1.3. Control Variable: Ridership

To serve as a control, variable monthly ridership data between January 2006 and December 2007 were obtained from Coast Mountain Bus Company. The purpose of the variable was to control for variation in the number of passengers. For the seasonal and monthly analyses the three dependent variables will be divided by ridership to create monthly incident rates. This will essentially control changes in the number of passengers, but also is beneficial in that it controls for the different number of days for different months and seasons. However, Coast Mountain Bus Company only aggregates ridership by month, which allows for one to readily control for the number of passengers on buses for the seasonal and monthly analyses, but make the weekly comparisons difficult. The closest, although not necessarily the ideal solution to overcome such over-aggregation is to break down the data by weeks by counting how many days in each week is represented for a particular month's ridership and dividing it by that portion of ridership. For example most months have more than 28 days (4 weeks), so the dependent variables for each of the four weeks for January 2006 will be divided by the proportion of ridership in which each of those seven days represents for that month ($7/31$). The remaining 4 days will be divided by that portion of the month's ridership ($4/31$) and the portion of the ridership for the next month ($3/28$). A limitation of this approach is that it does not precisely account for ridership or changes in the numbers of passengers in the way that the monthly analyses do and this will therefore be one drawback related to the weekly analyses. Finally, although there is no statistical advantage to doing so, for easier readability in the tables, each composite will be multiplied by 10,000,000 to create seasonal, monthly and weekly incident rates per 10 million passengers.

CHAPTER 6.

Univariate, Correlational, and Regression Analyses

6.1. Current Study

First, 1-way ANOVA tests will be conducted to determine if there is a significant seasonal effect for incidents of nonaggressive violence, aggressive violence, total violence, and for each type of attack. Then, Pearson product-moment correlational tests will be performed to determine if a positive and significant relationship exists at a monthly and weekly level between explanatory variables and incidents of nonaggressive violence, aggressive violence, total violence, and each type of attack against transit drivers. Finally, ordinary least squares (OLS) analyses will also be employed at the monthly and weekly level to determine how much variance temperature can account for in the dependent composites. Correlational and OLS analyses have previously been used in time period studies examining the temperature-aggression link over years, months and days, and utilized to determine if there is a significant relationship and to explain the variation in violent crime rates.

6.2. Preliminary Analyses

Preliminary analyses revealed that there were a few outliers in the dependent variables. However, the decision was made to retain all values as there is no reason to believe that those values were recorded incorrectly and excluding them simply for the purpose of inflating a correlation decreases the validity of the results. Further, there were three instances where an attack occurred, but the type of attack was not specified by the bus company. Therefore those three instances were not included in the data analysis.²

² The 3 instances occurred on August 16 and December 11 of 2006, and on June 18 of 2007.

Also, ordinary least squares assumes that residuals are serially independent (Cohen, Cohen, West, & Aiken, 2003), however the use of time-series data in multiple regression analyses commonly has serially correlated residuals (Berry, 1993). Therefore, the Durbin-Watson test (discussed in Tabachnick & Fidell, 2007) was used to test for the presence of first-order autocorrelation and results showed no autocorrelation of concern.³ In addition, early analyses revealed there were a number of weeks when no incidents occurred. As a result, it may turn out that there are not enough reported incidents against transit drivers per year to accurately measure the temperature aggression phenomenon at the weekly level (i.e., under aggregation), which is why the data have also been aggregated at the monthly and seasonal level to determine if hotter months and seasons are associated with increased incidents.

6.3. Descriptive Statistics

Descriptive statistics were generated for the seasonal, monthly and weekly analyses. The statistics included all of the main explanatory and dependent variables of interest. The means, standard deviations, minimum and maximum values for each time period analysis model are included in Tables 1 to 3.

Table 1 includes the 3 seasonal dependent composites, the 6 seasonal individual bus attacks and seasonal ridership. The table includes means, standard deviations, minimums and maximums for each variable.

³ 1.5 < DW < 2.5.

Table 1. Seasonal Descriptive Statistics for Attacks against Bus Drivers

Variable	<i>M</i>	<i>SD</i>	<i>Min</i>	<i>Max</i>
Ridership	1.677	7.047	15744268.330	17693498.670
Nonaggressive violence ^a	5.620	2.150	2.040	8.590
Aggressive violence ^a	6.030	0.850	4.450	7.240
Total violence ^a	11.650	2.450	6.490	14.620
Spat at ^a	0.680	0.470	0.180	1.390
Spat on ^a	2.250	0.720	1.380	3.560
Spat on face ^a	1.410	0.250	0.950	1.620
Verbal threat ^a	2.700	1.430	0.180	4.280
Physical assault ^a	3.430	0.860	2.480	5.190
Assault with a weapon ^a	1.190	0.670	0.380	2.020

^a Ridership included in seasonal incident rates (rates per 10,000,000 passengers).

Note. Means and standard deviations rounded to two decimal places; $n = 8$ seasons (2×4).

Table 2 lists the main explanatory variable mean monthly temperature (°C), monthly ridership and the 9 dependent variables. As depicted, the average mean monthly temperature ranged from a minimum of 3.00 to a maximum of 18.80 °C ($M = 10.44$, $SD = 5.30$). Although it appears that temperatures in Vancouver do not get very hot, it is important to remember that the current study is using mean monthly temperature rather than mean high monthly temperature. Theoretically it makes little difference whether mean monthly temperature or mean monthly high temperature is used as they both tend to share much of the same variance ($r = .998$, $p < .01$). Also there are some months where no incidents occurred. Similar to the seasonal analyses, each variable was divided by monthly ridership and multiplied by 10,000,000 to create monthly attack rates. Lastly, the descriptive statistics for the weekly analyses are included in Table 3.

Table 2. Monthly Descriptive Statistics for the Main Explanatory and Dependent Variables

Variable	<i>M</i>	<i>SD</i>	<i>Min</i>	<i>Max</i>
Temperature (°C)	10.440	5.300	3.000	18.800
Ridership	1.677	1.279	14680948.000	18909421.000
Nonaggressive violence ^a	5.620	2.540	0.660	10.580
Aggressive violence ^a	6.030	1.590	3.280	10.040
Total violence ^a	11.650	2.990	5.250	17.860
Spat at ^a	0.680	0.740	0.000	2.840
Spat on ^a	2.250	1.130	0.560	2.430
Spat on face ^a	1.410	0.660	0.000	3.070
Verbal threat ^a	2.700	1.870	0.000	6.620
Physical assault ^a	3.430	1.730	0.610	6.500
Assault with a weapon ^a	1.190	0.790	0.000	3.010

^a Ridership included in monthly incident rates (rates per 10,000,000 passengers).

Note. Means and standard deviations rounded to two decimal places; $n = 24$ months.

Table 3. Weekly Descriptive Statistics for the Main Explanatory and Dependent Variables

Variable	<i>M</i>	<i>SD</i>	<i>Min</i>	<i>Max</i>
Temperature (°C)	10.490	5.460	-2.270	20.410
Effective temperature(°C)	11.260	6.400	-2.270	23.590
Ridership	3.861	3.347	3153899.610	4440087.750
Nonaggressive violence rate ^a	5.660	4.300	0.000	18.130
Aggressive violence rate ^a	6.030	3.460	0.000	17.490
Total violence rate ^a	11.690	5.780	0.000	30.720

^a Ridership included in weekly violence rates (rates per 10,000,000 passengers).

Note. Means and standard deviations rounded two decimal places; $n = 104$ weeks.

Table 3 includes the main explanatory variables weekly mean temperature (°C), estimated weekly ridership and mean effective temperature (°C) followed by the 3 dependent composites nonaggressive violence rate, aggressive violence rate and total violence rate. As depicted, the average mean weekly temperature ranged from a minimum of -2.27°C for both explanatory variables and to a maximum of 20.41°C and 23.59°C (temperature and effective temperature respectively). As aforementioned, it makes no difference whether mean or mean high temperature is used as they both tend

to be highly correlated. Also there were many weeks where no incidents occurred (violence = 13, violent aggression = 7, and total violence = 1). Similar to the seasonal and monthly analyses, each variable was divided by weekly ridership and multiplied by 10,000,000 to create monthly attack rates.

6.4. Results

6.4.1. Warmer Seasons and Aggression

All of the dependent variables were tested for a significant seasonal effect through the use of a 2 x 4 (year X quarter) analysis of variance (ANOVA). Those dependent variables include the three dependent composites: (a) nonaggressive violence, (b) aggressive violence, and (c) total violence. In addition, each type of attack was also tested, including spat at, spat on, spat on face, verbal insult, physical assault, and assault with a weapon. The results of those tests are included in Table 4.

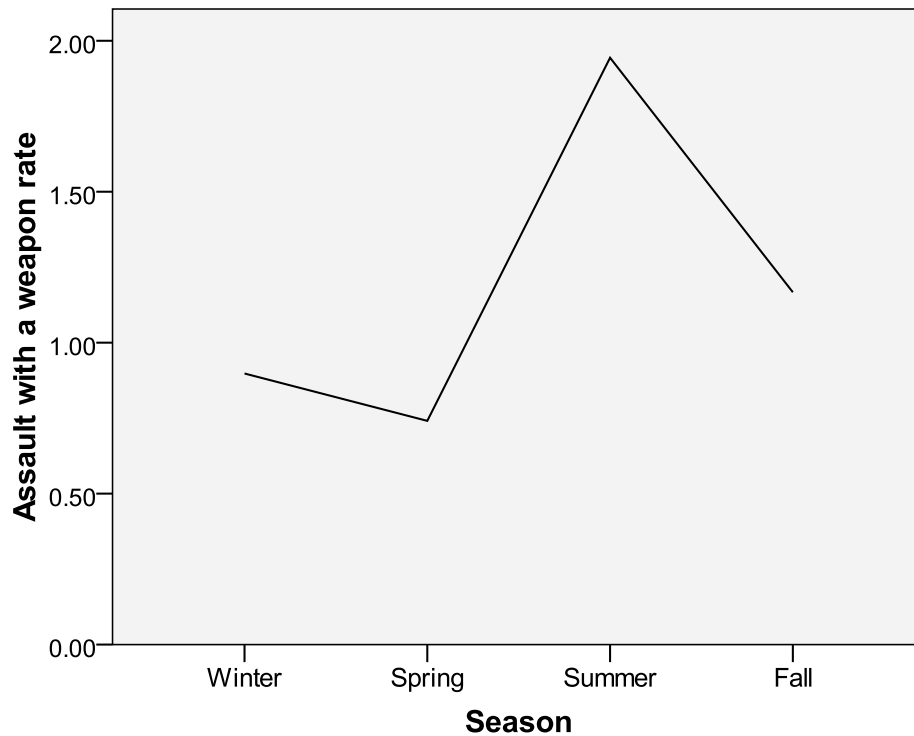
Table 4. Seasonal 1-way ANOVA of Attacks against Bus Drivers

Variable	F	Sig.
Nonaggressive Violence	0.839	.488
Aggressive Violence	1.225	.327
Total violence	1.299	.302
Spat at	0.631	.603
Spat on	0.743	.539
Spat on face	0.513	.678
Verbal threat	0.567	.643
Physical assault	1.242	.321
Assault with a weapon	3.701*	.029

$n = 8 (2 \times 4)$; * $p < .05$.

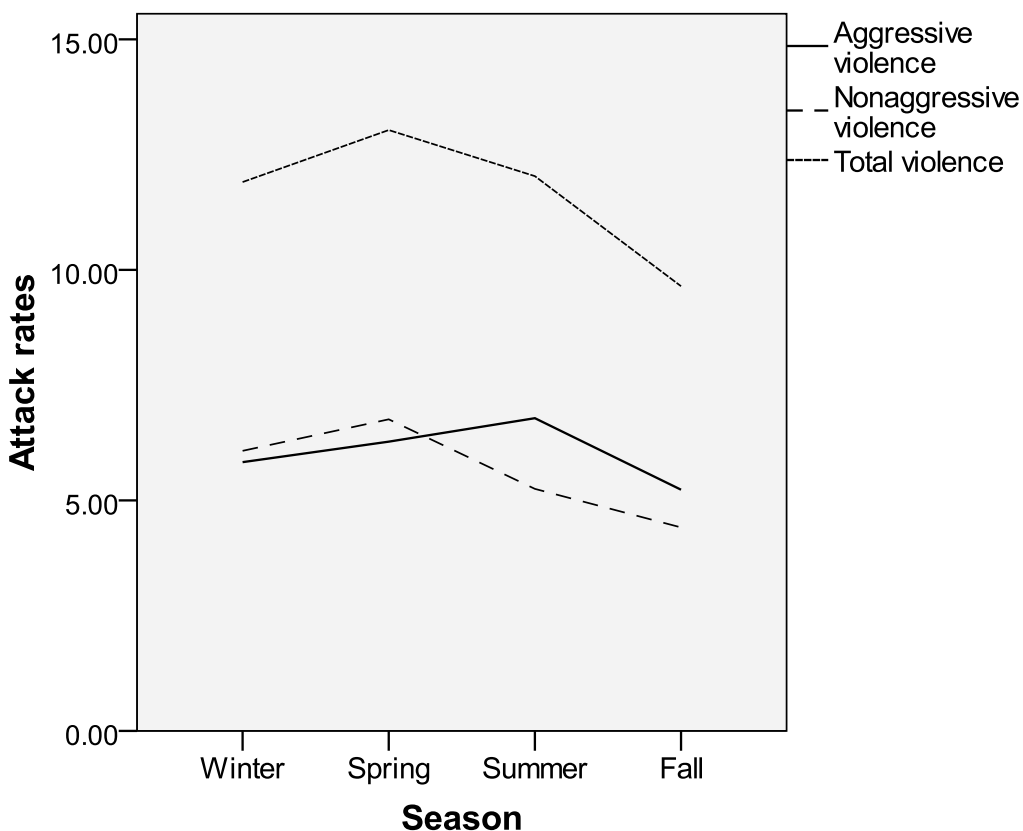
The results indicate that there was no significant seasonal effect in any of the dependent composites, however, the most serious aggressive attacks, 'assault with a weapon', did show a significant seasonal effect $F(3, 20) = 3.701, p < .05$. That effect was further probed through the use of a line graph (see Figure 4).

Figure 4. Seasonal Assault with a Weapon Rate



Further, although aggressive violence did not obtain significance, it is interesting to note that it had the highest attack rate in the summer quarter ($M = 5.83, 6.18, 6.89, 5.23$ assaults per 10 million passengers for Winter, Spring, Summer, and Fall respectively), a trend that was not observed for nonaggressive or total violence. Those results were also illustrated through the use of a line graph (see Figure 5).

Figure 5. Seasonal Nonaggressive Violence, Aggressive Violence, and Total Violence Rates



As shown in Figures 4 and 5, acts of aggressive violence peaked during the summer months even after controlling for the number of passengers per season. Although aggressive violence as a composite did not obtain statistical significance, the most serious act of aggressive violence did obtain significance. Acts of nonaggressive violence and total violence did not obtain statistical significance and peaked in the spring and declined thereafter. In summary, the results tend to show a peak of aggressive violence (12.5% above expected yearly seasonal mean) during the summer which is the warmest quarter of the year.

6.4.2. Warmer Months and Aggression

Mean monthly temperature was compared to the three dependent attack rate composites: nonaggressive violence, aggressive violence, and total violence. In addition, each attack rate was analysed individually in order to address potential misclassification of the dependent composites. The results of those comparisons are shown in Table 5.

Table 5. Monthly Bivariate Correlations for the Explanatory and Dependent Variables

Variable	Temperature (°C)	Sig.
Nonaggressive violence	.145	.249
Aggressive violence	.411*	.023
Total violence	.342	.051
Spat at	-.063	.384
Spat on	.301	.076
Spat on face	-.056	.397
Verbal threat	.040	.426
Physical assault	.221	.150
Assault with a weapon	.389*	.030

* $p < .05$, $n = 24$ months.

As shown in Table 5, there were two variables that are positively and significantly correlated with environmental temperature. Those variables include: aggressive violence ($r = .411$, $p < .05$) and assault with a weapon ($r = .389$, $p < .05$). It is noted that none of the least serious attacks (i.e., violence with low reactive aggression) correlated significantly with temperature, whereas the most serious and aggressive attacks were significantly and positively correlated with temperature. Furthermore, total violence was marginally significant.

The significant relationships were further assessed using OLS regression analyses to determine how much variation in those attack rates can be accounted for by environmental temperature, and to test for a possible curvilinear relationship. Regression analyses revealed that temperature accounted for 16.9% of the variation in violent aggression ($F(1, 22) = 4.477$; $p < .05$) and 15.1% of the variation in assault with a weapon ($F(1, 22) = 3.926$; $p < .05$). Further, when temperature² was added to the model it did not obtain significance for any of those dependent variables, an indication that the

relationships were linear rather than curvilinear. The following line graphs support this contention (see Figures 6 and 7). A quadratic best fit line with a 95% confidence interval was included in the graphs and indicated that at lower temperatures there appeared to be no relationship between temperature and incidents of aggression, however as temperatures increased a linear relationship was revealed.

Figure 6. Line Graph Depicting the Relationship between Mean Monthly Temperature and Aggressive Violence Rate

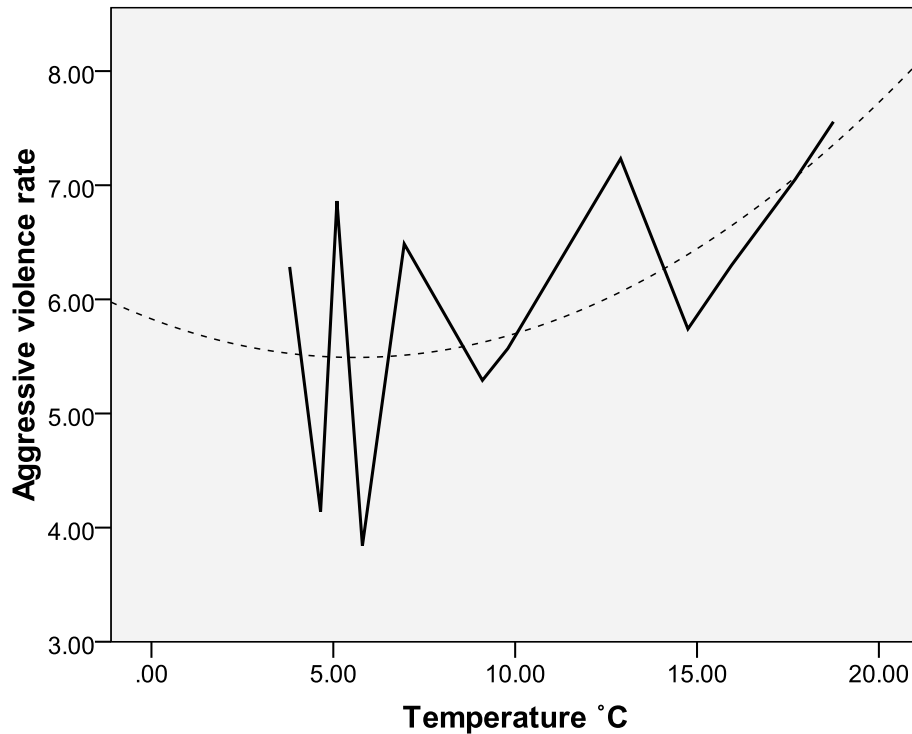
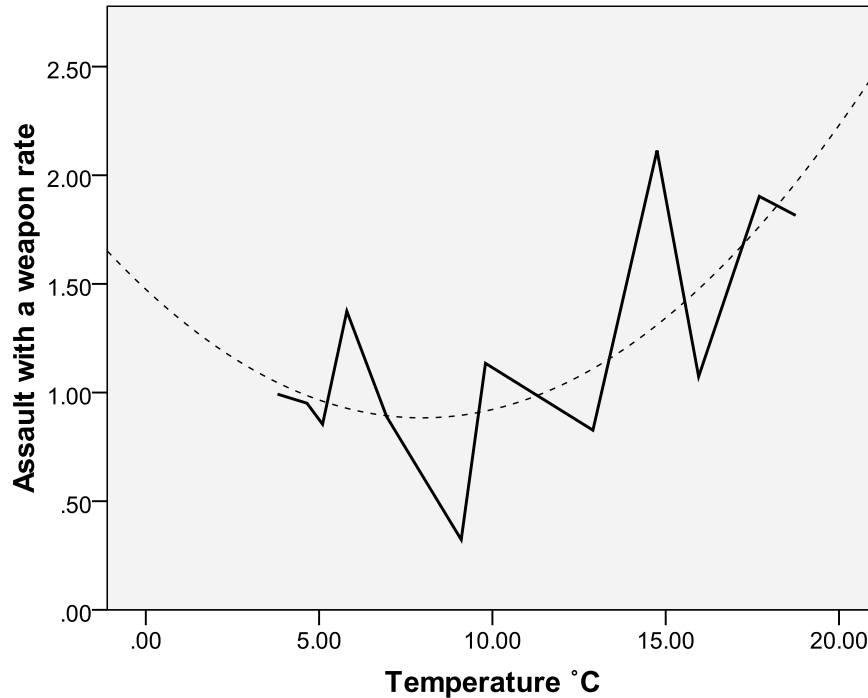


Figure 7. Line Graph Depicting the Relationship between Mean Monthly Temperature and Monthly Assault with a Weapon Rate



6.4.3. Warmer Weeks and Aggression

Mean weekly temperature and effective temperature (heat index) was compared to the three dependent attack rate composites nonaggressive violence, aggressive violence, and total violence. Each individual attack could not be compared to temperature in the weekly analyses as there were not enough attacks per year to aggregate the data at a weekly level. The results of those comparisons are shown in Table 6.

Table 6. Weekly Bivariate Correlations for the Explanatory and Dependent Variables

Variable	Temperature <i>r</i>	Sig.	Effective Temperature <i>r</i>	Sig.
Nonaggressive violence	.068	.245	.082	.204
Aggressive violence	.143	.074	.157	.056
Total violence	.136	.084	.155	.058

**p* < .05, *n* = 104 weeks.

As shown in Table 6, there were no composites that significantly correlated with environmental temperature or effective temperature. The largest correlation observed for the three composites was for aggressive violence ($r = .157$), however this correlation is very low and was only marginally significant. When temperature² (temperature squared) and effective temperature² were added to temperature in exploratory regression analyses they did not reach significance for any of those dependent composites.

6.4.4. Number of Passengers and Attacks against Drivers

Monthly temperature and ridership data were compared to the raw violence data (Table 7). Results revealed that when ridership was not factored into the calculations between temperature and the violent aggression composite and assault with a weapon, the correlations decreased slightly, but were still significant ($r = .409$, $p = .24$ and $r = .377$, $p = .035$ respectively). Temperature still accounted for 16.7% of the variation in violent aggression and 14.2% of the variation in assault with a weapon (without ridership controlled).

Table 7. Monthly Ridership and Temperature Correlated with Raw Violence Data

Variable	Temperature (°C)	Sig.	Ridership	Sig.
Nonaggressive violence	.147	.246	.265	.106
Aggressive violence	.409*	.024	.318	.065
Total violence	.335	.055	.383*	.032
Spat at	-.045	.418	.349*	.047
Spat on	.291	.084	.418*	.021
Spat on face	-.027	.450	.252	.118
Verbal threat	.043	.420	-.022	.459
Physical assault	.128	.276	.128	.276
Assault with a weapon	.377*	.035	.179	.202

* $p < .05$, $n = 24$ months.

The correlation between ridership and the variables spat at and spat on was also positive and significant ($r = .349$, $p = .047$ and $r = .418$, $p = .021$ respectively). More pointedly, ridership accounted for 12.2% of the variation in spat on and 17.5% of the variation in spat at. The results were further probed by collapsing all of the 'spitting'

categories into one composite. Results revealed that ridership explained 27.8% ($r = .527, p = .004$) of the variation in the 'spitting' composite. Furthermore, the correlation for total violence was significant ($r = .383, p = .042$) with temperature accounting for 14.7% of its variance.

CHAPTER 7.

Discussions and Future Directions

7.1. Discussion

The present study was designed to investigate attacks on transit drivers as a function of ambient temperature by comparing warmer seasons to cooler ones, and by correlating monthly and weekly temperatures with the bus attack variables and aggressive and nonaggressive violence composites. In general, the results indicated a positive relationship between environmental temperature and incidents of violent aggression as well as a positive relationship between the number of passengers and select categories of violence.

7.1.1. *Warmer Seasons and Violent Aggression*

For the seasonal analyses, the most aggressive type of attack incident, ‘assault with a weapon’, demonstrated a significant seasonal effect with the most attacks occurring during the summer quarter. The aggressive violence composite also showed a peak incident rate during the summer, a result that was not observed for the other two composites (see Figure 5). Those results are consistent with Anderson’s (1987) assertion that “the temperature-aggression model predicts a greater incidence of violent crime in the second and third quarters because those quarters are the hottest in the United States” (p. 1163). Although ‘assault with a weapon’ was highest in the summer (see Figure 4), it was the lowest in the spring. That result may be because of the small sample size at the individual attack level or because temperatures in Vancouver only become uncomfortably hot during the third quarter of the year and this is the time that the most serious and aggressive incidents peaked.

7.1.2. Warmer Months and Violent Aggression

As hypothesized, the most aggressive and serious bus attack incidents were positively and significantly related to temperature. As noted in Table 5, temperature was correlated moderately with aggressive violence ($r = .411, p < .05$) and accounted for 16.9% of its variance. Temperature was also significantly and positively correlated with the most serious violent incident 'assault with a weapon' ($r = .389, p < .05$) and accounted for 15.1% of the variance. Temperatures curvilinear component did not obtain significance when added to the aggression analyses, indicating that the relationship between temperature and those incidents of violent aggression was linear rather than curvilinear, at least at higher temperatures. Upon first glance, some may argue that such increases in aggression during higher temperatures could be attributable to more passengers being intoxicated during the summer months. However, careful perusal of the data in raw form did not show any increases in transit drivers' attributing attacks to intoxicated passengers during the summer months. Also, if a higher proportion of passengers are expected to be intoxicated in the summer, one would also theorize that there would be a higher proportion during December as well since liquor sales and consumption increase dramatically in that month (BC LDB, personal communication, November 11, 2009). However, analysis of the data revealed that no such peaks occurred in December in the bus attack data.

7.1.3. Warmer Weeks and Violent Aggression

The weekly analyses did not show the same trends as those depicted in the seasonal and monthly analyses as temperature and effective temperature were not significantly related to any of the three dependent composites. However, the correlation was positive and stronger for violent aggression than violence with low aggression ($r = .158, p = .056$ and $r = .082, p = .204$ respectively). The lack of a significant correlation at the weekly level may be in part due to the under aggregation of bus attacks (not enough attacks per week) and a high number of missing values. Further, the weekly ridership control was only an approximate calculation of the true weekly number, likely resulting in some measurement bias. Although results garnered from the more aggregated analyses (seasons and months) are less 'direct' measures of the

phenomenon, they are nonetheless comparable to results reported in other time period research. Future research would benefit from having data with higher attack counts so that shorter time periods can be analyzed. Moreover, all of the analyses could be improved by controlling for other factors such as gender and age.

7.1.4. Number of Passengers and Attacks against Drivers

When monthly temperature was compared to the raw data the correlations for violent aggression and assault with a weapon decreased slightly, an indication that controlling for population routines is an important factor when examining temperature-aggression. That factor was tested directly in the present study by correlating ridership with the raw data. Interestingly, results revealed a positive and significant relationship between ridership and spat at, spat on, and total violence. With the exception of verbal threats, ridership also correlated positively with all categories of violence, a finding that lends support for routine activities theory in explaining some increases in violence. Ridership was also significantly related to total violence, although that may be because spat at and spat on are included within that composite as none of the categories of violent aggression reached significance.

Overall, the results provide some support for Hypothesis 1 (seasonality of violently aggressive attacks), more support for Hypothesis 2 (monthly temperature and aggressive violence), but failed to provide backing for Hypothesis 3 (weekly temperature and aggressive violence). It should be noted that the former two hypotheses have more valid controls and are more statistically sound due to larger aggregation of incidents. Finally, Hypothesis 4 was generally supported as ridership positively correlated with five out of the six attack incidents and all of the composites. Interestingly, ridership accounted for 27.8% of the variation in the number of passengers spitting at or on transit drivers. However, the aggressive composite and most serious attack 'assault with a weapon' appeared to be better explained by temperature (with ridership controlled) than ridership (16.9% vs. 9% and 15.1% vs. 10.5% of variance explained respectively). The results presented here suggest in part that routine activities theory may be better at explaining less serious types of violence against transit drivers throughout the year while

the heat hypothesis better accounts for more serious crimes of emotional or reactive aggression during periods of higher temperatures.

7.1.5. Additional Analyses

Following the statistical analyses and interpretations for the 2006-2007 bus attack data, additional bus attack and ridership data for 2008 became available. In order to further pursue the study of bus attacks for 2008 the data was collected, formatted,⁴ and added to the 2006-2007 data. The results were similar to original findings, but not as strong perhaps accounted for by the unprecedented coolness of the summer.

7.1.5.1 Warmer Seasons

The most serious incident rate 'assault with a weapon' peaked in the summer quarter (see Appendix B). The incident 'spat on' and the composite 'aggressive violence' both showed a similar trend, but not nearly as pronounced (see Appendix B). The other two violence composites did not show any clear peak or trend and remaining attack incident rates also did not show any particular seasonal trend and are therefore not presented.

7.1.5.2 Warmer Months

In the monthly analyses the correlation for violent aggression shrank from $r = .411$ to $r = .287$, but was still significant ($p < .05$). The correlation for the most serious type of attack 'assault with a weapon' remained virtually the same $r = .389$ to $r = .328$ (both $p < .05$). Interestingly, the violent incident 'spat on' achieved significance when the 2008 data were added ($r = .390$, $p < .01$). However, since 'spat on' is part of a larger composite of spitting, dividing it into smaller behaviours may not be representative of the actual behaviour.

⁴ There was one instance on January 18, 2008 where the same incident (physical assault) was recorded by the bus company twice. Only one instance was included in the analyses; $N = 142$.

7.1.5.3 Warmer Weeks

When the 2008 data were included in the 2006-2007 weekly analyses the correlations for aggressive violence and total violence slightly increased ($r = .147$, $p < .05$ and $r = .165$, $p < .05$ respectively). Nonaggressive violence was not significant ($r = .107$, $p = .091$). Those findings are interesting considering that there were no significant findings in the 2006-2007 weekly data. Generally, the correlations at the weekly level are low and do not explain very much variance.

7.1.5.4 Number of Passengers

Lastly, when ridership was compared to the raw data for 2006-2008 it no longer obtained significance with any of the dependent variables or composites, but still obtained a positive correlation ($r = .248$, $p = .072$). This finding was consistent with the other three hypothesis that also showed weaker relationships when the 2008 data were included in the analyses. However, it must be noted that since there were not very many attacks during 2008, the results for all of the analyses for that year must be interpreted cautiously.⁵ In comparison to the mean number of bus attacks for 2006 and 2007 ($n = 235$) there was a 39.6% decrease in total bus attacks in 2008. During that period of time there were no known policy changes or decreases in ridership at Coast Mountain Bus that may have accounted for the reduction.

In addition to the above, the mean temperature for 2008 was reportedly 9.8°C, matching years 1984 and 1996 as having the second lowest mean annual temperature over the last 25 years⁶ (see Appendix C). That is interesting since the temperatures in Vancouver are already relatively temperate, and the temperature effect may be stronger at higher temperatures (C. Anderson, personal communication, October 26, 2009). In addition, the summer of 2008 in Metro Vancouver started out very wet and cool: “At times, western Canadians wondered if this was going to be the year without summer. By August 1, spring-summer temperatures ranged three to five degrees below normal” (Environment Canada, 2008b, ¶17). In fact, Metro Vancouver and the surrounding area

⁵ $N = 142$ attacks.

⁶ The mean annual high temperature was also the second coolest from 1984-2008.

made one of Environment Canada's (2008a) top regional highlights of 2008 due to the colder than average start to the summer:

At the beginning of June, when British Columbia residents expect warmth and bountiful sunshine, many along the Pacific coast shivered instead in record-breaking cold and wet weather. Numerous daily record-low temperatures were newly established. Victoria and Vancouver set records for the lowest highs on June 6 and 9. (¶4)

The wet and cool weather of the summer of 2008 may have lessened rates of aggressive violence. According to Simister and Van de Vliert (2005) wet weather leads to a decrease in aggression as rain is likely to mitigate the effects of temperature. However, one speculates whether such a decrease in temperature could account for the large decrease (39.1%) in total reported incidents.

Generally the analyses suggest that aggression does increase during periods of higher temperatures and demonstrated a significant heat effect for violently aggressive incidents. In addition, results indicated that routine activities theory may also be useful in explaining increases in instrumental violence. Although time period studies are not designed to be direct measures of the temperature and aggression phenomenon, through the use of triangulation with the results from geographic region and laboratory studies, confidence in the results obtained strengthen when all levels point to the same conclusion (Anderson & Anderson, 1996; Yasayko, 2007). The results from the present study are further understood using Boyanowsky's (1999, 2007) Ecs-TC syndrome as a guide for exploring the data.

7.2. Theory: Ecs-TC Syndrome

Boyanowky's (1999, 2007) Ecs-TC syndrome considers different research and other speculations made regarding aggression in heat, such as Zillman's excitation transfer (1983, 1988) model regarding arousal and aggression, elements of Berkowitz's (1989) cognitive neoassociation model and instigating factors from Bandura's 'social learning analysis' of aggression (Bandura, 1973). In a recent article, Boyanowsky (2007) propounds that people experiencing negative affect due to heat may be enduring:

conflict between the body's attempts to thermoregulate and their motivation to respond to perceived threats or attacks in their environment and that under the conditions of reduced cognitive discriminatory powers created by such heat stress, they lash out, at least initially, and if the response they experience is retaliatory or equally provoking, even more aggression follows that contributes once again to emotional and physiological disequilibrium. (p. 6)

As Boyanowsky (1999) describes, when an individual is experiencing negative affect due to heat they are more likely to misattribute or personify (similar to Berkowitz's 1989 cognitive neoassociation model) their negative feelings to an external source that they perceive as being responsible for their frustration or distress. In the current study this external source happened to be the transit drivers who may have been doing something as mild as missing a stop or questioning bus fare. It has been asserted that when frustration is accompanied by negative affect an individual is more likely to "lash out impulsively at some target, particularly if they are not incapacitated and the aggression does not require prolonged or deliberate effort" (Berkowitz, 1988, p. 10). Consistent with the Zillman's (1983) excitation transfer theory, when an individual is already physiologically aroused (due to heat) and becomes angry due to something occurring in their immediate environment (e.g., a bus driver missing a stop) they may transfer that state of heightened arousal to the situation at hand. Again, even a minor infraction by a transit driver may possibly be all that is necessary for the Ecs-TC syndrome to manifest in passengers. The results from the present study indicate that the most aggressive violent incidents against transit drivers increased as a function of temperature, while nonaggressive violent incidents did not show the same increase. However, it should be noted that the decision to retaliate may vary from individual to individual as every person's threshold to aggress violently in a public environment likely varies due to differences in socialization (Bandura, 1973).

More generally, the Ecs-TC syndrome can successfully be used as a theoretical tool to better understand the results from various studies on temperature-aggression because it accounts for the different interpretations arising from various theoretical perspectives. For example, it is compatible with routine activities theory in that if warmer weather increases social contact, and if those parties coming into contact with one another are also experiencing emotional cognitive stress, then an aggressive altercation is more likely to ensue. While negative affect escape theory has been used to explain

decreases in aggression at higher temperatures, the Ecs-TC syndrome already treats a state of negative affect as a given for individuals that are enduring uncomfortable temperatures, and is also compatible with the notion that the specific social circumstances and potential avenues for escape can influence whether or not a cumulative aggressive dynamic will form. The Ecs-TC syndrome considers many propositions from the various theoretical positions as implicit, and also explains why certain geographical regions have higher rates of aggression and violent crime than others. Specifically, individuals in societies with colder climates tend to develop more instrumentally aggressive cultural practices in order to acquire a means of subsistence and tend to commit crimes such as robbery during the coldest time of the year when resources are scarce. Individuals living in societies with hot climates however, tend to be in a constant state of “thermoregulatory stress” which reduces their emotional tolerance for responding aggressively to stresses in the surrounding environment, thus making violent altercations more common (Boyanowsky, 1999, p. 269). Also, the syndrome accounts for differences in aggression manifesting during cold temperatures compared to warm temperatures. However, it should be noted that acclimatization to warmer temperatures reduces thermoregulatory stress in humans living in warmer climates and likely accounts for differences in the rates of violent aggression reported in other temperature-aggression studies. In the current study violent aggression was shown to be positively correlated with temperature, however the line graphs depicted spikes of aggression around 5°C, a finding similar to results obtained in Yasayko’s (2007) research in major Canadian cities. Interpreted through Ecs-TC syndrome and classical environmental criminological theory those results could suggest possible increases in instrumental aggression during periods of colder temperatures, a finding that should be considered in future research on temperature-aggression.

As demonstrated, the Ecs-TC syndrome not only reconciles debates in the literature stemming from the different theoretical perspectives, but is also helpful in explaining cultural evolution in response to environmental determinants and differences in aggression in hot and cold temperatures. Nevertheless, the current study is not without its shortcomings.

7.3. Limitations

There are a number of limitations in the current study that should be noted. The first limitation relates to sample size. Since the violent and aggressive incidents were aggregated over different periods of time the analyses did not measure temperature and aggression concomitantly. Anderson and Anderson (1996) assert that the use of aggregated data can make cross-level inferences problematic, and refers to this problem as an “ecological fallacy” (p. 744). Therefore, due to this aggregation and the fact that correlational data were used one cannot imply causality since those procedures are not ‘direct tests’. Although triangulation does help overcome this issue, it is not a flawless solution for determining causality (Anderson, 1987). The present study can only determine if violent and aggressive incidents are higher during warmer weeks, months, and during certain seasons, but not necessarily if they occur on the hottest days of those time periods. Also, there were not enough bus attack incidents per year to test the relationship between weekly temperature and individual weekly incidents, but rather only the composites. Furthermore, the monthly ridership data were broken down by week, reducing the validity of that control at the weekly level of analyses.

Another potential drawback is that there may be other spurious variables that also correlate with temperature that may actually influence aggression. For example, another hidden variable (e.g., pollution, sunlight, unpleasant odours or alcohol consumption) could be responsible for influencing violent aggression rates. Nonetheless, temperature was retained in the above analyses as it is the most theoretically sound explanatory variable used in temperature-aggression research.

Another possible weakness is in relation to how violence and aggression are operationalized. Violence and aggression were not conceptualized as discrete terms, but rather as continuous as they overlap to a certain degree, making it difficult to detect differences between the two variables than if more discrete operationalizations were used. Therefore, it is possible that the composites were not true or perfect measures of the behaviours described due to the continuous nature of the variables.

Furthermore, the present data may suffer from minor reporting bias that could influence the results generated due to issues related to voluntary reporting by transit bus

drivers and employee turnover. Also, there are likely individual differences in temperament and personality traits of drivers that would influence reporting and the likelihood of an incident occurring.

The lack of very hot weather in Vancouver is another potential limitation (C. Anderson, personal communication, October 26, 2009) and could be why the current study did not obtain higher correlations between temperature and the most aggressive incidents. It would be preferable to test the relationship between temperature and aggression in a city that experiences higher temperatures in the summer as such a locale would provide more variance at the higher temperatures to examine attack rates. Nonetheless, the lack of empirical studies examining temperature and aggression in regions with cooler climates gives purpose for the current study demonstrating the universality of the phenomenon. Furthermore, those that live in more temperate climates such as Vancouver may not be as well acclimatized to heat as those living in hotter regions with less extreme temperature variations, therefore the geographical setting for the present study may well be justified.

Lastly, when the 2008 attack data were analyzed in conjunction with the 2006-2007 data the correlation between temperature and the violent aggression composite decreased (although still significant), however this may be partially explained by the abnormally cool and wet summer of that year. Regardless of that limitation and the others noted above, the results of the current study add additional support for the temperature-aggression hypothesis and routine activities theory, and are interpreted using Boyanowsky's (1999, 2007) definitions of aggression and violence.

7.4. Implications and Future Directions

The research reported here has important implications for climate change, since temperature increases have been shown to be related to increases in violent crime rates. As aforementioned, Anderson and colleagues (2000) claim that "for each 1°F increase in average temperature, the United States experienced 4.58 additional murders/assault crimes per 100,000 population" (p. 123), a statistic that translates to 13,740 additional violent crimes in the US per 1°F increase in annual mean temperature. Those findings are important given the recent concerns among climatologists with

respect to global warming. In Metro Vancouver and the surrounding coastal region where the present study was conducted the annual mean temperatures are predicted to increase from anywhere between 2 and 6°C by 2080 (Walker & Sydneysmith, 2008). Temperature extremes will be even more pronounced in the North and if acclimatization is important in dampening the heat effect on violent aggression there may be more profound effects in that region (Takaro, personal communication, April 10, 2010). Furthermore, such climatic changes have implications for criminological theory and societal policy.

7.4.1. General Criminological Theory

The proposed research has implications for sociological/criminological analyses of aggressive offenses and decision making in the judicial realm. Many criminological theories contend that social strains give rise to aggressive crimes. Further empirical support for the temperature-aggression relationship may well indicate that unpleasantly hot weather underlies one type of aggression-producing social strain, and could also suggest that such 'strain' instigates aggressive inclinations as a result of negative cognitive affect. Such findings have important implications for the judicial sphere as judges and jurors could consider aggressive crimes committed when temperatures are very high to be somewhat less blameworthy than similar offenses carried out in more moderate environmental conditions (i.e., manslaughter vs. murder). In fact, that idea has been around since the time of the Ottoman Empire when an individual who committed a murder was considered by law to be less culpable if the murder had been committed when hot winds were blowing (Brockes & Burkeman, 2001; "Sirocco", 1967, p. 516). The effect of extreme temperatures may be one social strain that can be treated as a mitigating factor by the judicial system. In addition to the general criminological ramifications of extreme temperatures, there is a need to integrate the temperature-aggression research into a larger framework for identifying the effects of the environment on human health and behaviour.

7.4.2. Societal Policy

There are implications for official policy in terms of environmental design and control, individual empowerment and other macro approaches. Environmental design can increase perceptions of open space and minimize opportunities for population density, while natural land cover can ameliorate 'heat islands' in urban areas, that reportedly can increase the temperature of the surrounding environment by 12°C [U.S. Environmental Protection Agency (USEPA), n.d.]. Efficient urban design will not only reduce the surrounding ambient temperature, but will also reduce the electricity required for air-conditioning in those areas (USEPA, n.d.). Reducing energy saves money and is a necessary step to lower energy producing emissions that contribute to global warming. Further, Rotton and Cohn (2000a) argue that "At a behavioural level, it can be argued that differences in architectural styles (e.g., concrete block vs. wood construction, covered sidewalks in southern cities), air-conditioning, and number of swimming pools make it easier to cope with high temperatures" (p. 1079). Other possibilities include water fountains, cooling centres and workspace temperature controls. In addition, school, prison, home and workplace climate controls may also be beneficial (Anderson, 2001; Anderson & Anderson, 1998). Anderson et al. (1997) indicate that measures such as air-conditioning in prisons decrease aggressive incidents that can have important implications with regard to devoting resources to either hiring another guard versus improving the living conditions for the inmates. Finally, large thermometers and electronic warning signs may, through attention redirection, ameliorate the worst effects in the way they did in Boyanowsky's (1999) research.

Moreover, public education can serve to increase individual empowerment. Informing the public to limit the use of alcohol or drugs that affect thermoregulation during times of increased temperature are two suggestions. Also, as mentioned, Boyanowsky (1999) contends if people are made aware that temperature affects emotions then they will be less likely to attribute their negative feelings to others in their surrounding environment. Public awareness may therefore benefit and promote individual and larger responses to rising ambient temperatures.

The potential solutions listed above are just components of a much larger response related to rising temperatures. Ostry et al. (2008) indicate that there needs to

be better cooperation among government, health authorities and other agencies to adapt to the current and future problems related to climate change. Educating the public to help mobilize a larger response between the public and other stakeholders is another important response in adapting to climate change (Ostry et al.). Although the link between rising temperatures and aggressive behaviour has been empirically documented, the exact mechanisms involved have not been precisely determined. Research in the area remains exploratory and needs to address shortcomings in the literature and to identify more precisely the physiological mechanisms at work at the individual level. Future research in the area of temperature-aggression is necessary to formulate practical responses that are compatible with the larger responses discussed.

References

- Aiken, L.S., & West, S.G. (1991). *Multiple regression: Testing and interpreting interactions*. Newbury Park, CA: Sage.
- Anderson, C.A. (1987). Temperature and aggression: Effects on quarterly, yearly, and city rates of violent and nonviolent crime. *Journal of Personality and Social Psychology*, *52*(6), 1161-1173.
- Anderson, C.A. (1989). Temperature and aggression: Ubiquitous effects of heat on occurrence of human violence. *Psychological Bulletin*, *106*, 74-96.
- Anderson, C.A. (2001). Heat and violence [Electronic version]. *Current Directions in Psychological Society*, *10*(1), 33-38. Retrieved March 19, 2010, <http://www.psychology.iastate.edu/faculty/caa/abstracts/2000-2004/01A.pdf>
- Anderson, C.A., & Anderson, D.C. (1984). Ambient temperature and violent crime: Tests of the linear and curvilinear hypotheses. *Journal of Personality and Social Psychology*, *46*(1), 91-97.
- Anderson, C.A., & Anderson, K.B. (1996). Violent crime rates studies in philosophical context: A destructive testing approach to heat and southern culture of violence effects. *Journal of Personality and Social Psychology*, *70*, 740-756.
- Anderson, C.A., & Anderson, K.B. (1998). Temperature and aggression: Paradox, controversy, and a (fairly) clear picture. In R. Geen & E. Donnerstein (Eds.), *Human aggression: Theories, research and implications for policy* (pp. 247-298). San Diego, CA: Academic Press.
- Anderson, C.A., Anderson, K.B., & Deuser, W.E. (1996). Examining an affective aggression framework: Weapon and temperature effects on aggressive thoughts, affect, and attitudes. *Personality and Social Psychology Bulletin*, *22*, 336-376.
- Anderson, C.A., Anderson, K.B., Dorr, N., DeNeve, K.M., & Flanagan, M. (2000). Temperature and aggression. In M. Zanna (Ed.), *Advances in Experimental Social Psychology*, *32*, 63-133. New York: Academic Press.
- Anderson, C.A., Bushman, B.J., & Groom, R.W. (1997). Hot years and serious and deadly assault: Empirical tests of the heat hypothesis. *Journal of Personality and Social Psychology*, *73*(6), 1213-1223.
- Anderson, C.A., & DeNeve, K.M. (1992). Temperature, aggression, and the negative affect escape model. *Psychological Bulletin*, *111*(2), 347-351.
- Angilletta, M.J. (2009). *Thermal adaptation: A theoretical and empirical synthesis*. New York: Oxford University Press.

- Auliciems, A., & DiBartolo, L. (1995). Domestic violence in a subtropical environment: police calls and weather in Brisbane. *International Journal of Biometeorology*, 39, 34-39.
- Bandura, A. (1973). *Aggression: A social learning analysis*. Englewood Cliffs, NJ: Prentice-Hall. Retrieved March 19, 2010, from: <http://www.questia.com/PM.qst?action=openPageViewer&docId=9694054>
- Baron, R.A. (1979). Aggression and heat: The 'long hot summer' revisited. In A. Baum, J.E. Singer, & S. Valins (Eds.), *Advances in environmental psychology* (pp. 57-84). Hillsdale, NJ: Erlbaum.
- Baron, R.A., & Bell, P.A. (1976). Aggression and heat: The influence of ambient temperature, negative affect, and a cooling drink on physical aggression. *Journal of Personality and Social Psychology*, 33(3), 245-255.
- Baron, R.A., & Ransberger, V.M. (1978). Ambient temperature and the occurrence of collective violence: The "Long, Hot Summer" revisited. *Journal of Personality and Social Psychology*, 36(4), 351-360.
- Bartol, C.R., & Bartol, A.M. (2008). *Criminal behavior: A psychosocial approach* (8th ed.). Upper Saddle River, NJ: Prentice Hall.
- Bazett, H.C. (1927). Physiological responses to heat. *Physiological Reviews*, 7, 531-599.
- BC Ministry of Environment. (2007). *Environmental trends in British Columbia: 2007*. Retrieved March 20, 2010, from http://www.env.gov.bc.ca/soe/et07/EnvironmentalTrendsBC_2007.pdf
- Bell, P.A. (1992). In defense of the negative affect escape model of heat and aggression. *Psychological Bulletin*, 111, 342-346.
- Bell, P.A., & Baron, R.A. (1976). Aggression in heat: The mediating role of negative affect. *Journal of Applied Social Psychology*, 6(1), 18-30.
- Berkowitz, L. (1988). Frustrations, appraisals, and aversively stimulated aggression. *Aggressive Behavior*, 14, 3-11.
- Berkowitz, L. (1989). Frustration-aggression hypothesis: Examination and reformation. *Psychological Bulletin*, 106(1) 59-73.
- Berkowitz, L., Schrager, S.M., & Dunand, M.A. (2006). Shared suffering can mitigate adversely-generated aggression: On the role of the target's stimulus characteristics [Electronic version]. *Aggressive Behavior*, 32, 80-87.
- Berry, W.D. (1993). *Understanding regression assumptions*. Newbury Park, CA: Sage Publications.
- Boyanowsky, E. (1977). *The effects of ambient temperature on sexual arousal*. Unpublished Manuscript, Simon Fraser University, Burnaby, British Columbia, Canada.
- Boyanowsky, E. (1998). Self descriptions of symptoms of emotional arousal. Unpublished manuscript, Simon Fraser University.

- Boyanowsky, E. (1999). Violence and aggression in the heat of passion and in cold blood: The Ecs-TC syndrome. *International Journal of Law and Psychiatry*, 22, 257-271.
- Boyanowsky, E. (2007). Climate, aggression and crime: Worrisome implications of the Ecs-TC syndrome for a changing environment. Retrieved March 19, 2010, from http://www.library.utoronto.ca/iip/journal/MAIN6/Climate_and_crime.pdf
- Boyanowsky, E.O., Calvert-Boyanowsky, J., Young, J., & Brideau, L. (1981). Toward a thermoregulatory model of violence. *Journal of Environmental Systems*, 11, 81-87.
- Boyanowsky, E., & Yasayko, J. (2010). Environmental temperature and sexual arousal in humans and animals: A preliminary investigation. Unpublished manuscript, Simon Fraser University, Burnaby, British Columbia, Canada.
- Boyanowsky, E.O., Young, J., & Bailly, R. (1972). *The effects of environmental heat and cold on aggression*. Montreal, Quebec, Canada: Canadian Psychological Association.
- Brockes, E., & Burkeman, O. (2001, May 30). Blame it on the sunshine. *Guardian.co.uk*. Retrieved March 19, 2010, from <http://www.guardian.co.uk/weather/Story/0,,498326,00.html>
- Bushman, B.J., & Cooper, H.M. (1990). Effects of alcohol on human aggression: An integrative research review. *Psychological Bulletin*, 107(3), 341-354.
- Bushman, B.J., Wang, M.C., & Anderson, C.A. (2005a). Is the curve relating temperature to aggression linear or curvilinear? A response to Bell (2005) and to Cohn and Rotton (2005). *Journal of Personality and Social Psychology*, 89(1) 74-77.
- Bushman, B.J., Wang, M.C., & Anderson, C.A. (2005b). Is the curve relating temperature to aggression linear or curvilinear? Assaults and temperature in Minneapolis reexamined. *Journal of Personality and Social Psychology*, 89(1), 62-66.
- Calvert-Boyanowsky, J., & Boyanowsky, E.O. (1981). Tavern breath-testing as an alcohol countermeasure. *Transport Canada*, 1-100.
- Carlsmith, J.M., & Anderson, C.A. (1979). Ambient temperature and the occurrence of collective violence: A new analysis. *Journal of Personality and Social Psychology*, 37(3), 337-344.
- Ceccato, V. (2005). Homicide in São Paulo, Brazil: Assessing spatial-temporal and weather variations. *Journal of Environmental Psychology*, 25, 307-321.
- Chang, D.H. (1972). Environmental influences on criminal activity in Korea. *Criminology*, 10, 338-352.
- Cheatwood, D. (1988). Is there a season for homicide? *Criminology*, 26(2), 287-306.
- Cohen, D., & Nisbett, R.E. (1994). Self-protection and the culture of honor: Explaining southern violence. *Personality and Social Psychology Bulletin*, 20(5), 551-567.

- Cohen, J. (1941). The geography of crime. *Annals of the American Academy of Political and Social Sciences*, 217, 29-37.
- Cohen, J., Cohen, P., West, S.G., & Aiken, L.S. (2003). *Applied multiple regression/correlation analysis for the behavioral sciences* (3rd ed.). Mahwah, NJ: Lawrence Erlbaum Associates.
- Cohen, L.E., & Felson, M. (1979). Social change and crime rate trends: A routine activity approach. *American Sociological Review*, 44, 588-608.
- Cohn, E.G. (1990). Weather and crime. *British Journal of Criminology*, 30, 51-64.
- Cohn, E.G., & Rotton, J. (1997). Assault as a function of time and temperature: A moderator-variable time-series analysis. *Journal of Personality and Social Psychology*, 72, 1322-1334.
- Cohn, E.G., & Rotton, J. (2000a). Weather, disorderly conduct, and assaults: From social contact to social avoidance. *Environment and Behavior*, 32, 651-673.
- Cohn, E.G., & Rotton, J. (2000b). Weather, seasonal trends, and property crime in Minneapolis, 1987-1988: A moderator-variable time-series analysis of routine activities. *Journal of Environmental Psychology*, 20, 257-272.
- Cohn, E.G., & Rotton, J. (2003). Global warming and U.S. crime rates: An application of routine activity theory. *Environment and Behavior*, 35(6), 802-825.
- Cohn, E.G., & Rotton, J. (2005). The curve is still out there: A reply to Bushman, Wang, and Anderson's (2005) "Is the curve relating to temperature to aggression linear or curvilinear?" *Journal of Personality and Social Psychology*, 89(1), 67-70.
- Cotton, J.L. (1986). Ambient temperature and violent crime. *Journal of Applied Social Psychology*, 16(9), 786-801.
- DeFronzo, J. (1984). Climate and crime: Tests of an FBI assumption. *Environment & Behavior*, 16, 185-210.
- Dexter, E.G. (1899). Conduct and the weather. *Psychological Monographs*, 11(10), 1-103.
- Dunlop, M.P. (n.d.). *Biological effects of alcohol use: An overview*. Retrieved October 15, 2009, from <http://www.oregoncounseling.org/ArticlesPapers/Documents/ETOHBIOfx.htm>
- Environment Canada. (2008a). *Canada's top ten weather stories for 2008: Regional weather highlights 2008: What follows May? January*. Retrieved November 16, 2008, from http://www.ec.gc.ca/doc/smc-msc/2008/r5_eng.html
- Environment Canada. (2008b). *Canada's top ten weather stories for 2008: Runner-up stories for 2008: Would summer ever come to the west?* Retrieved November 16, 2008, from http://www.ec.gc.ca/doc/smc-msc/2008/s11_eng.html#s8
- Falk, G.J. (1952). The influence of the seasons on the crime rate. *The Journal of Criminal Law, Criminology, and Police Science*, 43(2), 199-213.

- Feldman, H.S., & Jarmon, R.G. (1979). Factors influencing criminal behavior in Newark: A local study in forensic psychiatry. *Journal of Forensic Science*, 24, 234-239.
- Field, S. (1992). The effect of temperature on crime. *The British Journal of Criminology*, 32, 340-351.
- Gaedeken, P. (1909). Contribution statistique a la reaction de l'organisme sous l'influence des agents meteorologiques. *Archives d'Anthropologie Criminelle et de Medecine Legale*, 24, 173-187.
- Ganjavi, O., Schell, B., & Cachon, J.C. (1985). Geophysical variables and behavior: XXIX impact of atmospheric conditions on occurrences of individual violence among Canadian penitentiary populations. *Perceptual and Motor Skills*, 61(6), 259-275.
- Goranson, R., & King, D. (1970). *The effects of heat waves on race riots*. Unpublished manuscript, York University, Toronto, Ontario, Canada.
- Haertzen, C., Buxton, K., Covi, L., & Richards, H. (1993). Seasonal changes in rule infractions among prisoners: A preliminary test of the temperature-aggression hypothesis. *Psychological Reports*, 72, 195-200.
- Harries, K.D. (1980). *Crime and the environment*. Springfield, IL: Charles C Thomas.
- Harries, K.D., & Stadler, S.J. (1983). Determinism revisited: Assault and heat stress in Dallas, 1980. *Environment and Behavior*, 15, 235-256.
- Harries, K.D., & Stadler, S.J. (1988). Heat and violence: New findings from Dallas field data, 1980-1981. *Journal of Applied Social Psychology*, 18, 129-138.
- Harries, K.D., Stadler, S.J., & Zdorkowski, R.T. (1984). Seasonality and assault: Explorations in inter-neighborhood variation, Dallas 1980. *Annals of the Association of American Geographers*, 74(4), 590-604.
- Heins, A.P. (1983). Hot and cold environments. In W.N. Rom (Ed.). *Environmental and Occupational Medicine* (pp. 733-741). Boston: Little, Brown.
- Hipp, J.R., Bauer, D.J., Curran, P.J., & Bollen, K.A. (2004). Crimes of opportunity or crimes of emotion? Testing two explanations of seasonal change in crime. *Social Forces*, 82(4), 1333-1372.
- Hollitscher, W. (1947). *Sigmund Freud an introduction: A presentation of his theory and a discussion of the relationship between psycho-analysis and sociology*. London: Kegan Paul, Trench, Trubner and Co.
- Huntington, E. (1945). *Mainsprings of civilization*. New York: John Wiley and Sons, Inc.
- Kenrick, D.T., & MacFarlane, S.W. (1986). Ambient temperature and horn honking: A field study of the heat/aggression relationship. *Journal of Environment and Behavior*, 18, 179-191.
- Landau, S.F., & Fridman, D. (1993). The seasonality of violent crime: The case of robbery and homicide in Israel. *Journal of Research in Crime and Delinquency*, 30, 163-191.

- LeBeau, J.L. (1994). The oscillation of police calls to domestic disputes with time and the temperature humidity index. *Journal of Crime and Justice*, 17, 149-161.
- Lee, S. (Director/Producer), & Ross, M. (Co-Producer). (1989). *Do the right thing* [Motion Picture]. United States: Universal Pictures.
- Leffingwell, A. (1892). *Illegitimacy and the influence of seasons upon conduct*. New York: Scribners.
- Lewis, L.T., & Alford, J.J. (1975). The influence of season on assault. *The Professional Geographer*, 27(2), 214-217.
- Linkowski, P., Martin, F., & DeMaertelaer, V.D. (1992). Effects of some climatic factors on violent and non-violent suicides in Belgium. *Journal of Affective Disorders*, 25, 161-166.
- Lombroso, C. (1899). *Crime: Its causes and remedies*. Boston: Little, Brown.
- Lombroso, G. (1972). *Criminal man, according to the classification of Cesare Lombroso-Ferrero*. [Original work published 1911]
- Michael, R., & Zumpe, D. (1983a). Annual rhythms in human violence and sexual aggression in the United States and the role of temperature. *Social Biology*, 30, 263-278.
- Michael, R., & Zumpe, D. (1983b). Sexual violence in the United States and the role of season. *American Journal of Psychiatry*, 140, 883-886.
- Michael, R., & Zumpe, D. (1986). An annual rhythm in the battering of women. *American Journal of Psychiatry*, 143, 637-640.
- Nisbett, R.E. (1990). Evolutionary psychology, biology, and cultural evolution. *Motivation and Emotion*, 14(4), 255-263.
- Nisbett, R.E. (1993). Violence and U.S. regional culture. *American Psychologist*, 48, 441-449.
- Nisbett, R.E., & Cohen, D. (1996). *Culture of honor: The psychology of violence in the south*. Boulder, CO: Westview.
- Ostry, A., Ogborn, M., Takaro, T., Bassil, K., & Allen, D. (2008). *Climate change and health in British Columbia*. Victoria, British Columbia, Canada: Pacific Institute for Climate Solutions.
- Palamarek, D.L., & Rule, B.G. (1979). The effects of ambient temperature and insult on the motivation to retaliate or escape. *Motivation and Emotion*, 3(1), 83-92.
- Perry, J.D., & Simpson, M.E. (1987). Violent crimes in a city: Environmental determinants. *Environment and Behavior*, 19, 77-90.
- Pettigrew, C.G. (1985). Seasonality and lunacy of inmate behaviour. *The Southern Psychologist*, 2, 41-46.

- Reifman, A.S., Larrick, R.P., & Fein, S. (1991). Temper and temperature on the diamond: The heat-aggression relationship in major league baseball. *Personality and Social Psychology Bulletin*, 17, 580-585.
- Rohles, F. H. (1974). The model comfort envelope and its use in current standards. *Human Factors*, 16, 314-322.
- Rotton, J. (1986). Determinism redux: Climate and cultural correlates of violence. *Environment and Behavior*, 18(2), 346-368.
- Rotton, J., & Cohn, E.G. (1999). Errors of commission and omission: Comment on Anderson and Anderson's (1998) "Temperature and aggression". *Psychological Reports*, 85, 611-620.
- Rotton, J., & Cohn, E.G. (2000a). Violence is a curvilinear function of temperature in Dallas: A replication. *Journal of Personality and Social Psychology*, 78(6), 1074-1081.
- Rotton, J., & Cohn, E.G. (2000b). Weather, disorderly conduct, and assaults: From social contact to social avoidance. *Environment and Behavior*, 32(5), 649-671.
- Rotton, J., & Cohn, E.G. (2001). Temperature, routine activities, and domestic violence: A reanalysis. *Violence and Victims*, 16(2), 203-215.
- Rotton, J., & Cohn, E.G. (2003). Global warming and U.S. crime rates: An application of routine activity theory. *Environment and Behavior*, 35(6), 802-825.
- Rotton, J., & Cohn, E.G. (2004). Outdoor temperature, climate control, and criminal assault: The spatial and temporal ecology of violence. *Environment and Behavior*, 36(2), 276-306.
- Rotton, J., & Frey, J. (1985). Air pollution, weather, and violent crimes: Concomitant time series analysis of archival data. *Journal of Personal and Social Psychology*, 49(5), 1207-1220.
- Rule, B.G., Taylor, B.R., & Dobbs, A.R. (1987). Priming effects of heat on aggressive thoughts. *Social Cognition*, 5(2), 131-143.
- Semenza, J.C., McCullough, J.E., Flanders, W.D., McGeehin, M.A., & Lumpkin, J.R. (1999). Excess hospital admissions during the July 1995 heat wave in Chicago. *American Journal of Preventative Medicine*, 16(4), 269-277.
- Semenza, J.C., Rubin, C.H., Falter, K.H., Selanikio, J.D., Flanders, W.D., Howe, H.L., & Wilhelm, J.L. (1996). Heat-related deaths during the July 1995 heat wave in Chicago. *The New England Journal of Medicine*, 335(2), 84-90.
- Shapira, A., Shiloh, R., Potchter, O., Hermesh, H., Popper, M., & Weizman, A. (2004). Admission rates of bipolar depressed patients increase during spring/summer and correlate with maximal environmental temperature. *Bipolar Disorders*, 6, 90-93.
- Shiloh, R., Munitz, H., Stryjer, R., & Weizman, A. (2007). A significant correlation between ward temperature and the severity of symptoms in schizophrenia inpatients: A longitudinal study. *European Neuropsychopharmacology*, 17, 478-482.

- Simister, J., & Cooper, C. (2005). Thermal stress in the U.S.A.: Effects on violence and on employee behavior. *Stress and Health, 21*, 3-15.
- Simister, J., & Van de Vliert, E. (2005). Is there more violence in very hot weather? Tests over time in Pakistan and across countries worldwide. *Pakistan Journal of Meteorology, 2*, 55-70.
- Sirocco. (1967). *Science News, 91*(3), 516. Retrieved January 22, 2010 from: <http://www.jstor.org/pss/3951396>
- Sylvester, S.F. (1972). *The heritage of modern criminology*. Cambridge, MA: Schenkan.
- Tabachnick, B.G., & Fidell, L.S. (2007). *Using multivariate statistics* (5th ed.). Boston: Pearson Education, Inc.
- Taylor, S.P., & Gammon, C.B. (1975). Effects of type and dose of alcohol on human physical aggression. *Journal of Personality and Social Psychology, 32*(1), 169-175.
- Taylor, S.P., Schmutte, G.T., Leonard, K.E., & Cranston, J.W. (1979). The effects of alcohol and extreme provocation on the use of a highly noxious electric shock. *Motivation and Emotion, 3*(1), 73-81.
- Tennenbaum, A.N., & Fink, E.L. (1994). Temporal regularities in homicide: Cycles, seasons, and autoregression. *Journal of Quantitative Criminology, 10*(4), 317-342.
- Tihonen, J., Räsänen, P., & Hakko, H. (1997). Seasonal variation in the occurrence of homicide in Finland. *American Journal of Psychiatry, 154*(12), 1711-1714.
- US Environmental Protection Agency (USEPA). (n.d.). *Heat island effect*. Retrieved November 26, 2009, from <http://www.epa.gov/hiri/>
- Van de Vliert, E. (2007). Climates create cultures. *Social and Personality Psychology Compass, 1*(1), 53-67.
- Van de Vliert, E., Schwartz, S.H., Huisman, S.E., Hofstede, G., & Daan, S. (1999). Temperature, cultural masculinity, and domestic political violence: A cross-national study. *Journal of Cross-Cultural Psychology, 30*, 291-314.
- Vrij, A., Van Der Steen, J., & Koppelaar, L. (1994). Aggression of police officers as a function of temperature: An experiment with the fire arms training system. *Journal of Community & Applied Social Psychology, 4*, 365-370.
- Walker, I.J., & Sydneysmith, R. (2008). British Columbia. In D.S. Lemmen, F.J. Warren, J. Lacroix, & E. Bush (Eds), *From impacts to adaptation: Canada in a changing climate 2007*, (pp. 329-386). Government of Canada, Ottawa, ON.
- Wilhelm, P. (2003). Climate, corruption, fertility and religion: Implications for entrepreneurship and economy. Retrieved March 19, 2010, from <http://www.sbaer.uca.edu/research/asbe/2003/pdfs/hub/20Wilhelm.pdf>
- Yasayko, J. (2007). *The influence of environmental temperature on violent crime rates in Canada*. Unpublished Honours Thesis, Simon Fraser University, Burnaby, British Columbia, Canada.

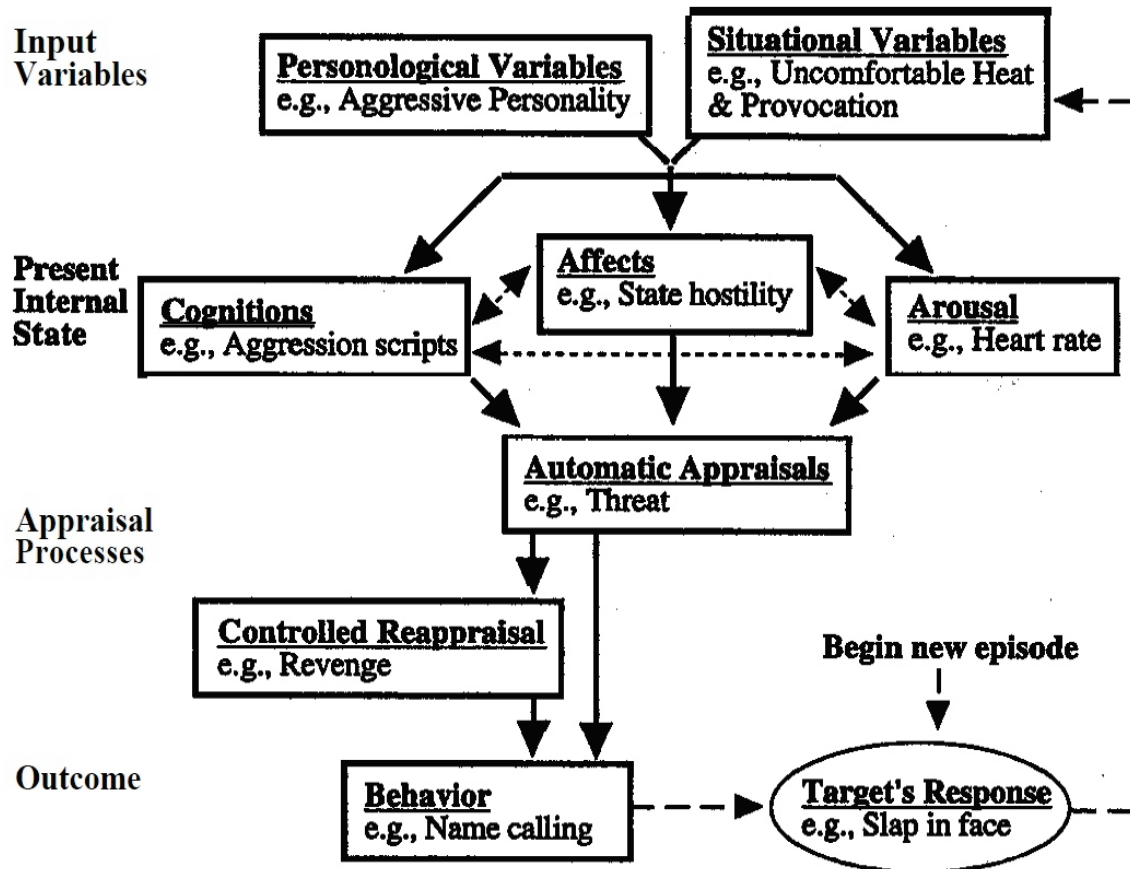
Zillman, D. (1983). Arousal and aggression. In R. Geen & E. Donnerstein (Eds.), *Aggression: Theoretical and empirical reviews, Vol 1. Theoretical and methodological issues* (pp. 75-101). New York: Academic Press.

Zillman, D. (1988). Cognition-excitation interdependencies in aggressive behavior. *Aggressive Behavior*, 14, 51-64.

APPENDICES

Appendix A.

General Affective Aggression Model



Note. Anderson et al. (2000), used with permission.

Appendix B.

Select Line Graphs for 2006-2008

Figure A1. Seasonal Mean Assault with a Weapon Rate

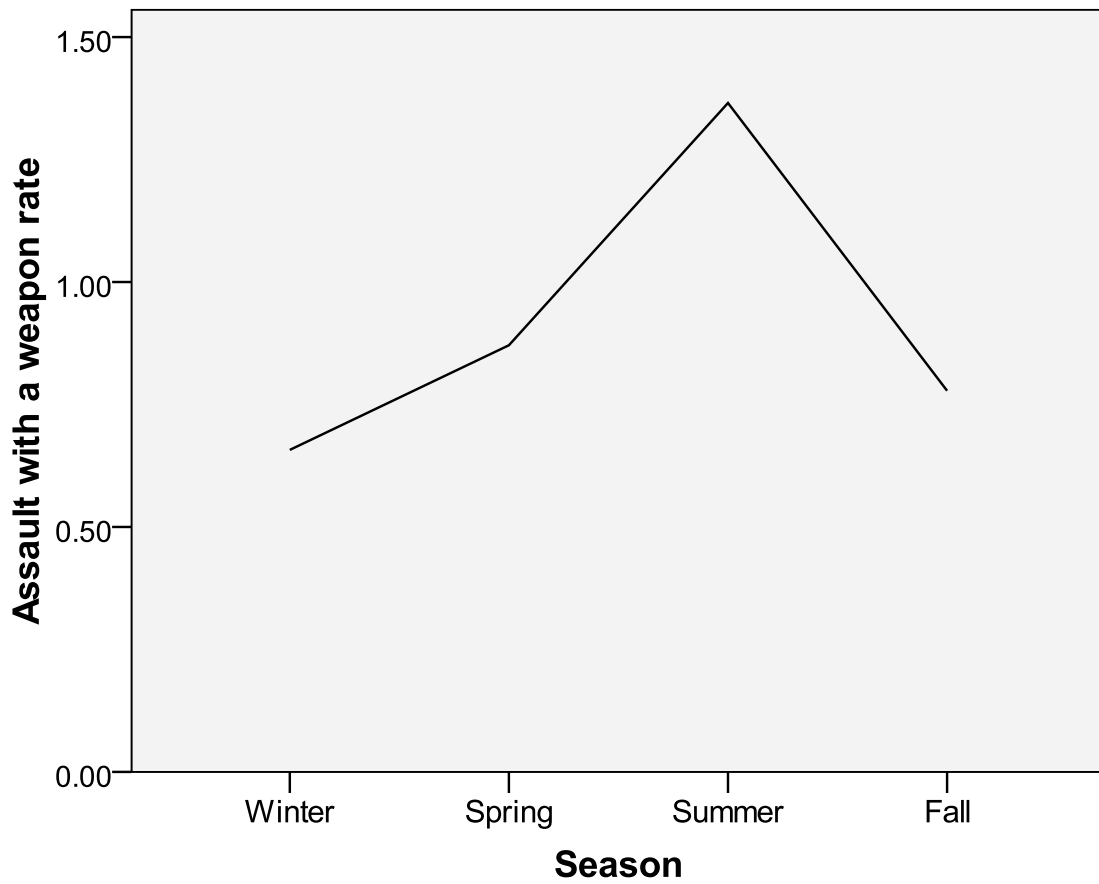


Figure A2. Seasonal Mean Aggressive Violence, Nonaggressive Violence, and Total Violence Rates

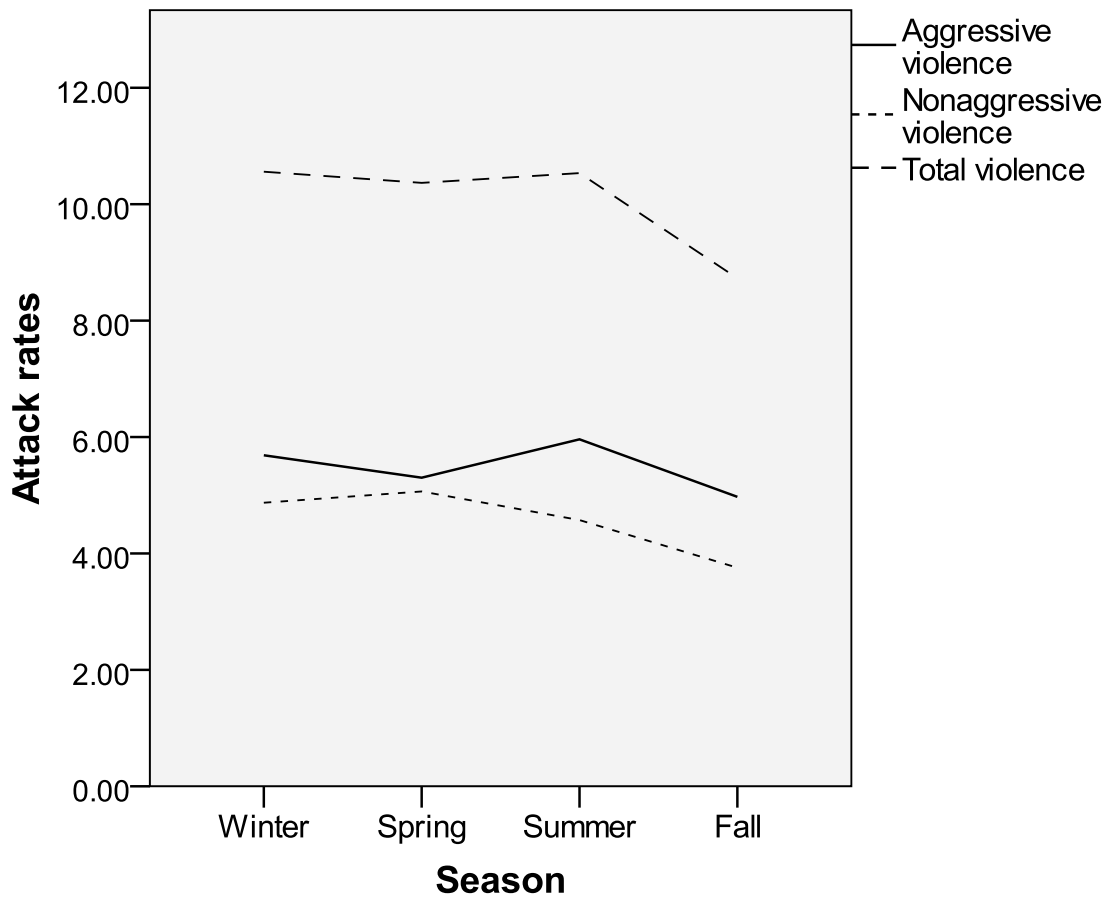
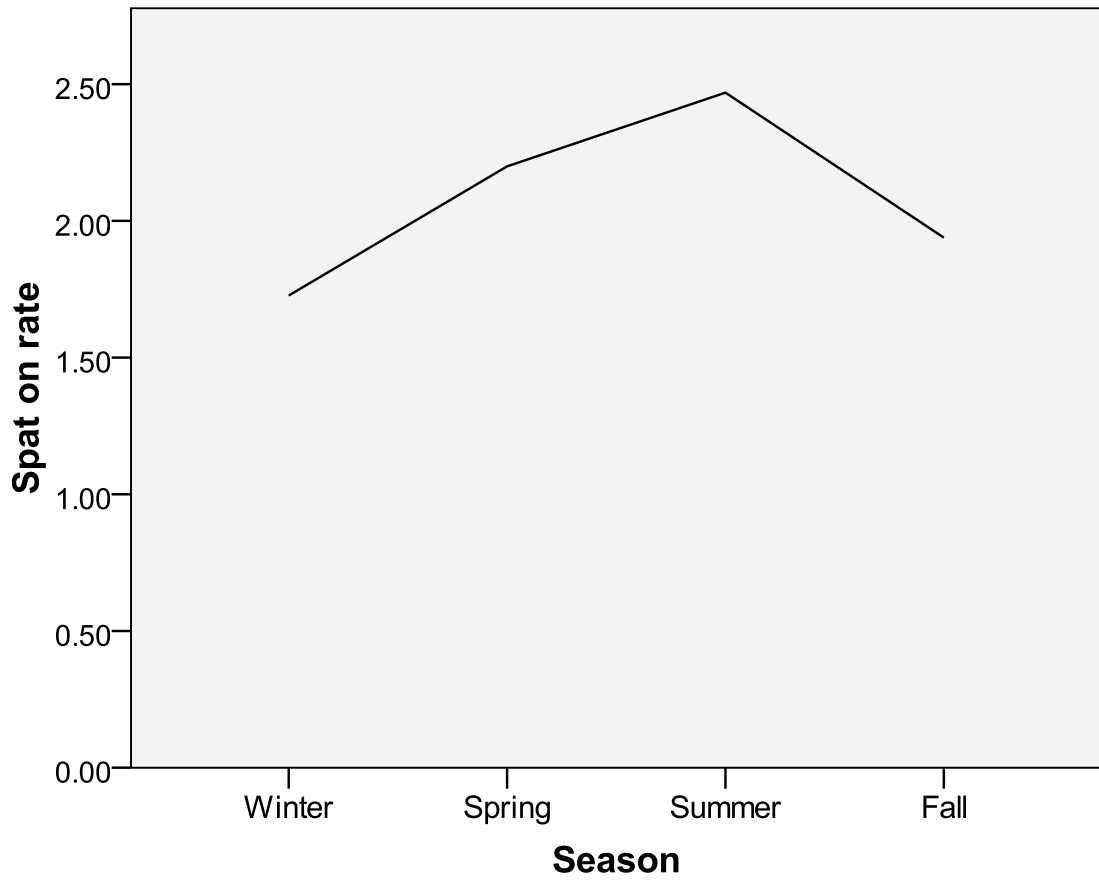


Figure A3. Seasonal Mean Spat on Rate



Appendix C.

Annual Mean Temperatures in Vancouver from 1984 to 2008

