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TEMPERATURE AND AGGRESSION: PARADOX, CONTROVERSY, AND A (FAIRLY) CLEAR PICTURE

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Our Lady of the Lake University

I pray thee, good Mercutio, let's retire;
The day is hot, the Capulets abroad,
And, if we meet, we shall not 'scape a brawl,
For now, these hot days, is the mad blood stirring.
                            Romeo and Juliet, *Shakespeare*

The day drags by like a wounded animal
The approaching disease, 92°
The blood in our veins and the brains in our head
The approaching unease, 92°
                  92° by Siouxsie and the Banshees, Tinderbox,
                            David Geffen Company, 1986

Imagine the following scenario. You are in your overpriced hotel room, reviewing your notes for an important presentation that you will be giving later in the day. The people next door have their television cranked to maximum volume. It is so loud that you can hear the dialogue as well as the gunfire and explosions; it is from Sylvester Stallone's movie *Judge Dredd.* Despite an earlier request to turn it down, the volume remains at an intolerable level. You pound on their door

to explain your situation and make one more appeal. The appeal is met by laughter and a comment on the legitimacy of your birth. How do you respond? We would guess that most readers of this chapter would feel angry, but would not emit any aggressive behavior.

Now, imagine the same scenario, but with one additional stressful factor. The hotel air conditioning is off, and the rooms and hallways are at least 92°F. Now what is the likelihood that you would aggress? Most people would agree that the hot temperature would indeed increase the likelihood of an aggressive response of some kind. Even if it is merely a verbal insult, the probability of a violent encounter occurring also increases, perhaps as the end result of a series of escalating verbally abusive exchanges.

This chapter is structured to address theoretical, empirical, and practical issues surrounding the temperature–aggression hypothesis. First, a brief history of the temperature–aggression hypothesis is presented. Second, a paradox involving violence and lethargy is described and resolved. Third, the major issues and theories surrounding heat effects are outlined, and an integrated model of aggression is provided. Fourth, several epistemological issues concerning empirical tests of various theories are discussed. Fifth, modern empirical studies are reviewed, and new results that bear on issues of current concern are presented. Finally, the empirical data base is more specifically compared to the major theories, noting convergences and contradictions, and pointing out fruitful lines of inquiry for future research.

A BRIEF HISTORY OF THE
TEMPERATURE–AGGRESSION HYPOTHESIS

Social commentators have noted weather effects on human behavior and have used heat-related imagery for thousands of years. Cicero (106–43 B.C.) noted that "The minds of men do in the weather share, dark or serene as the day's foul or fair." Shakespeare noted (in *The Merchant of Venice*) that "the brain may devise laws for the blood, but a hot temper leaps o'er a cold decree." Shakespeare explicitly referenced what presumedly was a commonly held belief in the society of his day in *Romeo and Juliet,* as in the opening quote linking hot temperatures to violent behavior.

Social philosophers, social geographers, and other students of behavior began to apply empirical methods to this theory in the late 1800s. Even earlier, Montesquieu traveled extensively and drew upon his observations in various writings. Heat effects were included in his observations. In *The Spirit of the Laws* he stated that, "You will find in the northern climates peoples who have few vices, enough virtues, and much sincerity and frankness. As you move toward the countries of the south, you will believe you have moved away from morality itself: the liveliest passions will increase crime. . . ." (Montesquieu, 1748/1989, p. 234). In this work, Montesquieu even espoused a physiological theory for why hot temperatures produced such extreme emotionality in the peoples who lived in hot southern climates.

It was some time before this type of informal observation of and speculation about heat effects was supplemented with more objective empirical methods. The earliest such study located was by Leffingwell (1892), who examined quarter of the year effects on two broad categories of violent crime in England and Wales in 1878–1887. Other early studies of the heat effect include those by Lombroso in Italy (and elsewhere) (1899/1911), Guerry in France (as cited in Brearley, 1932), Dexter (1899) in the United States, and Aschaffenburg (1903/1913) in Germany and France. Although the empirical methods were somewhat crude by modern standards, these early studies supported the prevailing theory that uncomfortably hot temperatures produce increases in violent behavior (for a review of this work, see Anderson, 1989).

THE TEMPERATURE–AGGRESSION PARADOX

Some of the early writings concerning heat effects contained a paradox that to this day remains unresolved. Specifically, hot temperatures are seen as having two effects that seem opposite and contradictory. On the one hand, hot temperatures are seen as increasing aggression. On the other hand, hot temperatures are also seen as robbing people of motivation, alertness, and energy. Aggression usually requires considerable energy or effort, especially the aggression examined in studies focusing on violent crimes such as assault and murder. Thus, the paradox: How can lethargic people behave violently? If heat makes people reluctant to engage in energetic activities, how can it produce increases in aggression?

Before attempting to resolve this paradox, it is important to ask whether it truly exists. There are two parts to consider, the "increases aggressive behavior" part and the "decreases effort/energy" part. Much of this chapter is devoted to discovering whether hot temperatures directly increase aggressive behavior. As most readers will have guessed by now, the evidence of such direct effects is overwhelmingly positive. Assuming that we are right (and that the later sections of this chapter are convincing to you, the reader), then we are left with the second part, whether hot temperatures also make people lethargic. There has been surprisingly little research on this question, perhaps because it is somewhat vague.

There are several ways of thinking about lethargy, including at a simple affect level (e.g., How do you feel?), at a physiological level (e.g., Is heart rate decreased?), and at a task level (e.g., Is cognitive performance lowered?). In addition, we can ask whether modern citizens of western society (e.g., U.S. college students) believe there is a true heat effect. We begin by examining this "Do you believe?" question.

STUDY 1: SOCIAL THEORIES ABOUT HEAT EFFECTS

The goal of Study 1 was to assess the social theories of our subject population concerning the relation of temperature to the several variables of interest in this domain: affect, arousal, and aggression. A questionnaire was developed to measure

subjects' social theories concerning the relation of both hot and cold temperatures to these variables.

Method

Procedures

Fifteen female and 7 male undergraduates at a large midwestern university participated in this experiment. Participants were given a two-page questionnaire, which was titled: "Beliefs about temperature, emotions, and behavior." They were instructed to "indicate your beliefs by circling a number for each item below." After completing the questionnaire, participants were thoroughly debriefed and thanked for their assistance.

Participants were asked six questions using the frame, "Compared to normal temperatures, what do you think the effect of (hot/cold) temperatures would be on (alertness and energy level, feelings of hostility and anger, aggression and violent behaviors)." Each question was answered on a five-point rating scale, with the lowest rating indicating a belief that the temperature (hot or cold) would decrease the target variable (i.e., alertness, hostility, or aggression), the midpoint indicating a belief in no heat effect, and the highest rating indicating a belief that the temperature would increase the target variable. The three questions concerning effects of hot temperatures and the corresponding three cold temperature questions were presented on separate pages. Participants were randomly assigned to completing the hot or the cold page first. This order manipulation allowed examination of the possibility that thinking about one type of heat effect (e.g., hot) would influence subjects' responses on the other (e.g., cold).

Results and Discussion

The six items and results are presented in Figure 10.1, in terms of average deviations from the scale midpoint of 3, which corresponded to a belief in no effect of temperature. There were no reliable effects of task order or of sex ($p > .05$), so subsequent tests ignored these factors. A t test was performed on each item mean to see whether it differed reliably from "no effect." As can be seen, hot temperatures were expected to have a very large impact on all three target variables. Compared to comfortable temperatures, participants believed that hot temperatures would produce a significant decrease in alertness and energy level [$M = 1.50$, $t(21) = -8.77$, $p < .001$], a significant increase in anger and hostility [$M = 4.64$, $t(21) = 13.24$, $p < .001$], and a significant increase in aggressive and violent behavior [$M = 4.45$, $t(21) = 10.14$, $p < .001$].

Participants also expected that cold temperatures (relative to comfortable ones) would have systematic effects on the target variables, but in every case the direction of the expected cold effect was opposite of the expected hot effect. Participants expected cold temperatures to produce a significant increase in alertness and energy level [$M = 3.64$, $t(21) = 2.32$, $p < .05$], a significant decrease in anger and hostility [$M = 2.45$, $t(21) = -2.83$, $p < .01$], and a significant decrease in aggressive and violent behavior [$M = 2.14$, $t(21) = -4.84$, $p < .001$].
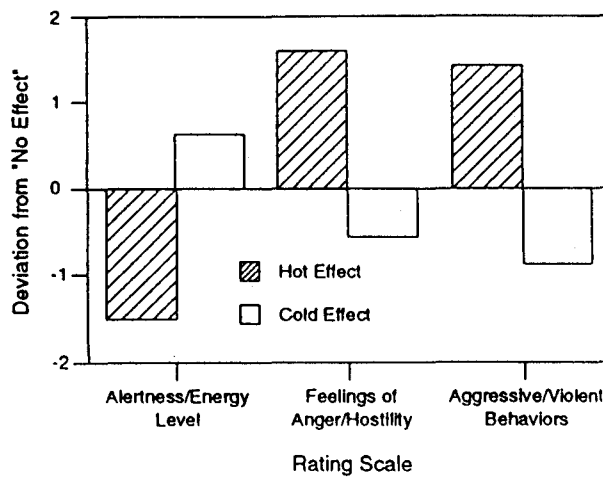
FIGURE 10.1   Social theories relating temperature to three dimensions.

Overall, these results confirm that people do have social theories relating temperature to a host of aggression-related variables.[1] The hot temperature paradox is also illustrated by these beliefs. Our participants believed that heat reduces alertness and energy levels, while simultaneously increasing aggressive behavior. The finding of opposite social theories for the effects of uncomfortably cold temperatures may prove useful in future research on the effects of temperature on aggression, especially in ruling out various alternative explanations that rely on suspicion or demand characteristics.

TEMPERATURE AND AROUSAL

A second part of the paradox question involves the actual effect of hot temperatures on arousal. Study 1 indicated that people believe that heat reduces alertness and energy, but what are its actual effects? This simple question turns out to have a complex answer. It depends on what one means by arousal.

In several experiments in our laboratories, we have shown that *subjective* perceptions of arousal, as measured by the self-report perceived arousal scale (Anderson, Anderson, & Deuser, 1996; Anderson, Deuser, & DeNeve, 1995), decrease at hot temperatures. Specifically, people assigned to play video games, perform a cognitive reaction time task, or do brief aerobic exercise in hot temperatures report feeling less aroused than people performing the same tasks in normal temperatures. Conversely, cold temperatures produce an increase in perceived arousal (Anderson et al., 1996).

[1]A larger study ($n = 55$) was also conducted using these same procedures and items. However, the order of hot versus cold questions was not varied. The result was a practically identical set of means, each of which differed significantly from the scale midpoint of "no effect."

Physiological arousal though, as assessed by changes in heart rate, complicates the picture. Hot temperatures systematically increase heart rate, relative to normal temperatures (Anderson et al., 1995, 1996). Interestingly, cold temperatures seem to produce decreases in heart rate under laboratory conditions (Anderson et al., 1996). Other research from a variety of laboratories produces heart rate results similar to ours (Bazett, 1927; Hardy, 1961; LeBlanc, 1975; Tromp, 1980).

TEMPERATURE AND PERFORMANCE

Performance on cognitive tasks seems to parallel the subjective arousal results. Hot temperatures reduce performance on various types of tasks. Tedious and repetitive tasks that involve a low level of physiological arousal are particularly susceptible to performance decrements in heat. Visual vigilance tasks are impaired when temperatures exceed 90°F (Mortagy & Ramsey, 1973; Pepler, 1958), sometimes as a result of perceptual distortions due to heat glare and shimmer (Kobrick & Johnson, 1991). Auditory vigilance decreases in temperatures above 100°F (Poulton, Edwards, & Colquhoun, 1974). Heat has been shown to impair performance in rifle marksmanship (Johnson & Kobrick, 1988, as cited in Kobrick & Johnson, 1991), flight simulations (Iampietro, Melton, Higgins, Vaughan, Hoffman, Funkhouser, & Saldivar, 1972), arithmetic tasks (Ramsey, Dayal, & Ghahramani, 1975), and short-term memory tasks (Wing & Touchstone, 1965, as cited in Kobrick & Johnson, 1991). Across tasks, those that are more interesting and arousing are less affected by increases in temperature as well as those that do not involve use of materials that become uncomfortable in heat such as metal surfaces and bulky protective clothing (Kobrick & Johnson, 1991). Few studies have been conducted on cold effects and performance, and the results do not warrant generalized summaries at this point in time. (For reviews of this literature, see Kobrick & Fine, 1983; Kobrick & Johnson, 1991).

PARADOX RESOLUTION

Although the effects of hot (and cold) temperatures on various kinds of variables are undoubtedly complex, no real paradox is seen in the position that hot temperatures can simultaneously decrease energy levels and increase aggressive behaviors. Although uncomfortable heat can decrease one's willingness to do a variety of things, it also increases one's irritability or state hostility (Anderson et al., 1995, 1996). Thus, any given provocation is received more negatively by a hot person than by a comfortable one. In other words, those kinds of aggression that are based on impulsive or affective reactions to provocation are likely to be increased by hot temperatures.

Although the focus of this chapter is on heat effects, it is important to consider another paradox. As will become apparent in our integrated model of aggression, discomfort appears to be the underlying factor in heat-induced aggression, suggesting that uncomfortably cold temperatures should also increase aggression.

However, real world violence does not appear to increase in cold temperatures. Doesn't this contradict the discomfort theory? Actually, it does not. The simple reason is that throughout most of human history and even in most modern societies, relief from cold discomfort is more available (via clothing, fire, heating systems) than relief is from heat discomfort. Thus, real world studies are not good sources of tests of cold effects. As seen in subsequent sections, cold discomfort does increase aggression in laboratory studies in much the same way as heat does.

MAJOR ISSUES IN THE STUDY OF HEAT EFFECTS

There are three major issues in the study of heat effects on aggression. The first one concerns whether temperature has a direct impact on aggressive tendencies. The second concerns theoretical explanations for the various heat effects observed in a wide variety of contexts. The third concerns the practical significance of findings on the temperature–aggression hypothesis.

EXISTENCE OF THE HEAT EFFECT

It is clear from dozens of studies (e.g., Anderson, 1989) that hot temperatures are associated with increased violence. Of course, it is also clear that race in the United States is strongly associated with performance on standardized intelligence tests, but mere association is not the same as causation. The race/IQ association is hotly contested for both political and methodological reasons. The most obvious scientific reason for doubting that race is causally linked to these large test score effects is that there is a well-developed body of evidence linking a host of theoretically relevant variables to test performance and race. In other words, race in 20th century U.S. society is confounded with a number of truly causal variables such as poverty. Thus, there is good reason to doubt that race has a direct impact on standardized test performance.

Similarly, in correlational studies of the temperature–aggression hypothesis, there may be complexities that artificially give rise to strong heat effects. The existence question in this chapter refers to whether there is a true direct causal effect of hot temperatures on aggression. By direct impact we mean one that occurs at a psychological level, having its impact on aggression via the individual's affective state, way of thinking, or arousal level.

It is important to distinguish between two nondirect ways in which hot temperatures may be linked to aggressive behavior. The first way, which consists of indirect links, causally links temperature to some external factor, which in turn is causally linked to aggressive behavior. For example, hot temperatures may be associated with increases in violent crime rates because of the kinds of routine activities that people "do" in hot weather versus cooler weather. An analogous indirect effect in the race/IQ domain might be that skin color influences the expectations of

teachers, whose behavior toward students of different races hinders the learning of certain racial groups while facilitating the learning of other racial groups.

The second nondirect way that temperature may be linked to aggressive behavior is via totally spurious links. For example, the common finding of higher violent crime rates in the "southern" cities of the United States may be a function of the higher proportion of impoverished and disadvantaged minorities in those cities, who typically have higher violent crime rates than other groups throughout the United States. Because temperature differences among cities do not "cause" the obtained socioeconomic and racial compositions of the cities, this temperature/violent crime link could be totally spurious. (However, as seen in a later section, controlling for socioeconomic and racial composition does not eliminate the heat effect in such studies, so it is not spurious.)

It is important to realize that the epistemological status of spurious links is not the same as that of indirect processes. Discovery that a particular heat effect disappears when spurious links are controlled weakens the temperature–aggression hypothesis by removing the spurious finding from the column of "successful predictions." However, discovery of indirect heat effects is largely irrelevant to the questions of whether there are true, causal direct effects of hot temperatures on aggressive behavior; surely there are many variables that influence the frequency and severity of aggression in modern society, some of which may correlate with temperature. The scholars' tasks in this area are to identify plausible causal influences on aggressive behavior, to develop testable hypotheses that allow for disconfirmation, to conduct tests of these hypotheses, and to refine the theories. Of course, if all the observed heat effects can be explained parsimoniously via an indirect route or are found to be spurious, then the answer to this first major issue, concerning the existence of direct heat effects, would be negative.

THEORETICAL POSITIONS

The second major issue asks, What are the major theories that might account for hot heat effects? Five such theories have been identified, and an integration of the most promising aspects of several of them has been provided in a broader model of affective aggression.

Biological Theories

Physiological theories of heat effects should be viewed on a different level of analysis from broader sociological, cognitive, and affective models. Biological theoretical explanations can be seen as complementing higher-level theories by suggesting the physiological mechanisms directly responsible for heat effects on emotions. This section briefly describes both a physiological theory of heat effects and the relation of thermoregulation to aggression.

Zajonc (1985, 1994; Zajonc, Murphy, & Inglhart, 1989) has proposed the innovative vascular theory of emotional efference, which focuses on the role of blood vessels in the cavernous sinus in cooling the blood that flows into the face

and brain. The degree to which the blood is cooled or heated influences the stimulation of emotional centers in the brain. Zajonc's theory grew out of Waynbaum's (1907) work, which posited that the facial muscles (through constriction) regulate the amount of blood that flows to the cerebrum, which in turn influences subjective feelings. Zajonc clarifies that facial muscles are merely one of many regulators of cerebral blood flow but maintains that constriction or relaxation of certain facial muscles can affect the cooling of venous blood flow to the brain. The cooling of the brain is suggested to release certain neurotransmitters that increase the positive affect.

Zajonc et al. (1989) reported increases in forehead temperature in German and American participants as they utter the German phoneme "ü", which constricts air flow to veins in the cavernous sinus, while reading stories aloud or repeating a tape-recorded voice, compared to no utterance of the "ü" or to utterance of phonemes that open the sinuses (e.g., "ah" and "e"). Participants in these studies reported less liking for the ü sound and stated that producing the non-ü sounds put them in a better mood than did generation of the ü. Zajonc et al. (1989) further found that cool air, when blown into the nostrils, both decreased forehead temperature and increased positive subjective feelings. In line with the vascular theory of emotional efference, he concluded that when cool air is introduced to the nostrils, as occurs with the utterance of certain sounds, the blood flowing from the nostrils up to the forehead and the brain is cooled, thereby cooling the brain and increasing pleasant, positive feelings in the individual.

Another biological approach relates to thermoregulation, the process that the body undergoes to heat or cool itself in response to uncomfortable temperatures. Several of the physiological processes involved in thermoregulation have also been linked to emotion. The amygdala, hypothalamus, and hippocampus are all highly neuronally interconnected and are important brain centers for thermoregulation and the release of both hormones and neurotransmitters related to aggression. For example, the hypothalamus releases acetylcholine in response to ambient cold, which increases body temperature. Acetylcholine has been shown to increase aggression (Reis, 1974). The male and female sex hormones of testosterone and estrogen have also been associated with aggression. Increases in testosterone have been linked to aggressive behavior in men and women (Blanchard & Blanchard, 1984), and decreases in estrogen and progesterone (as in the premenstrual phase) have been associated with female aggression (Buchanan, Eccles, & Becker, 1992). The production of testosterone is influenced by corticosteroids, which are released from the adrenal cortex when the body sweats.

The amygdala acts as an emotional computer that assigns affective significance to incoming stimuli (LeDoux, 1993). Its neurons are also responsive to changes in heart rate and blood pressure, which can vary with ambient temperature. Therefore, the amygdala can create aggressive interpretations and reactions as a function of sympathetic and parasympathetic autonomic responses to temperature.

The relation between thermoregulation and emotion is far from understood due to the complex interrelation of relevant neuronal centers, hormones, and

neurotransmitters. However, the interconnectedness of these systems suggests a relationship among ambient temperature, body temperature, and aggression.

Southern Culture of Violence

As evidenced in the earlier quote by Montesquieu (1748/1989), social theorists have long noticed an increase in violence in southern regions, which are closer to the equator. Theories of a U.S. southern culture of violence range from the sociological (e.g., Gastil, 1971; Hackney, 1970) to the evolutionary and economic (Nisbett, 1990, 1993).

Some sociological approaches focus on the relatively lengthy time period in which the South was an unsettled wilderness frontier (Gastil, 1971; Hackney, 1970). Others attribute the development of a southern culture of violence (SCV) to swashbuckling cavaliers who settled in the early South. The cavaliers held personal honor and virtue as ideals, which they combatively defended (Cash, 1941; Nisbett, 1993).

Of particular interest is Nisbett's theory of a southern culture of honor (Cohen & Nisbett, 1994; Nisbett, 1990, 1993). He posits that the livelihood of people who primarily settled in the South depended on a herding economy. In order to thrive in this economic system, male producers were required to be highly protective of their livestock from poachers. Because of the relative isolation that these men experienced, they alone defended their herds, their families, and their honor. These frontier people (adaptively) socialized their offspring to hold these aggressive defensive attitudes toward potential intruders as well as taught them the behaviors necessary to fight effectively (e.g., how to operate a gun).

Nisbett (1990, 1993) cites a variety of studies in support of this view and suggests that the culture of honor explains the regional differences in U.S. homicide rates. Of course this view also requires the assumption that once a culture of violence develops, it will persist even after the economic circumstances giving rise to it have shifted. Otherwise, the culture of honor would be irrelevant to aggression in urban environments.

Assumptions of some SCV theories have not been consistently supported by research. Bailey (1976), for example, reanalyzed Gastil's (1971) study of "southernness" effects on homicide rates and found that regional effects were greatly diminished when appropriate socioeconomic factors were controlled. Some studies have shown no differences in southern and nonsouthern samples in gun ownership (O'Connor & Lizotte, 1978) or violent attitudes (Erlanger, 1975). Nisbett (1993) provides the important caveat that southern violence is primarily linked to self-protection, so only homicides that occur in the interests of self-defense (or of personal honor) should (according to his theory) show regional differences. Similarly, southerners should not hold more general violent attitudes than northerners, rather southerners should endorse more violence for self-protection purposes.

In sum, the culture of honor view posits that the southern region of the United States has a socioeconomic history that has created a more violent culture than in northern regions. More specifically, this perspective predicts that the old south

should have higher violent crime rates than other regions of the United States. Although both the culture of honor and the temperature–aggression hypotheses attempt to explain the high homicide rate often found in southern U.S. cities, they need not be viewed as mutually exclusive. A southern culture of violence (or culture of honor) could (a) have an effect on violence that is independent of temperature or (b) have partially (or wholly) evolved due to hot temperatures. Although the latter supposition is impossible to test, critical tests of the former will examine the relationships among SCV, temperature, and violence.

Routine Activity Theory

Cohen and Felson (1979) developed routine activity theory (RAT) to explain the link between increases in crime and increases in temperature. This sociological view states that opportunities to commit crimes increase in the summer because social behavior patterns change. In the summer, people (potential victims as well as perpetrators) are more likely to leave their homes and their families. Increases in alcohol consumption and a reduction in guardianship have also been posited as crime-related warm weather behaviors (Cohn, 1990; Landau & Fridman, 1993).

RAT has been supported by some archival studies of the temperature–aggression relation (Cohen & Felson, 1979; Field, 1992) and not by others (e.g., Michael & Zumpe, 1986). Although heat and changes in social behavior patterns co-occur, they can, and probably do, have independent effects on aggressive behavior. Some proponents of RAT propose that the temperature–aggression effect is at least mediated by, if not an artifact of, changes in routine activities.

Negative Affect Escape Theory

Baron and Bell's negative affect escape theory (NAE; Anderson & DeNeve, 1992; Baron, 1972; Bell, 1992; Bell & Baron, 1976) focuses on the current state of the individual and their behavioral motives. According to this theory, negative affect increases as temperatures become uncomfortably hot or cold. Both aggressive and escape motives are believed to increase as negative affect increases. At high levels of negative affect, if escape from the situation is possible then escape motives overcome aggressive motives and escape behavior is expressed (and aggressive behavior is not). If escape is not perceived as an option (as in many laboratory experiments), more aggressive behavior should result at uncomfortable temperatures.

Most laboratory studies of this theory have manipulated temperature and anger. Those that support the NAE have found a temperature × anger interaction in which hot temperatures led to decreases in aggression in angry conditions and increases in aggression in nonangry conditions (Anderson & DeNeve, 1992). This interaction has not been found in some studies (Baron, 1972; Bell & Baron, 1977) and has occurred in the reverse fashion in at least one (Bell, 1980). Overall, laboratory data testing the NAE as applied to the temperature–aggression hypothesis are inconsistent (Anderson, 1989). Further studies involving behavioral measures

of aggression as well as those that pit aggressive and escape motives against each other are required to test the specific predictions of the theory.

Social/Cognitive Theories

Two theories that focus on the influence of environmental factors on aggressive cognitions and behaviors are (a) Bandura's (e.g., 1973) groundbreaking social learning theory (SLT) and (b) Berkowitz's (1984, 1993) contemporary cognitive neoassociation theory (CNT) of emotion. According to SLT, witnessing aggression leads to the acquisition, performance, and maintenance of aggressive behavior. An important aspect of this theory is that the aggressive behavior that is viewed can be encoded into memory and retrieved when the witness is faced with a similar situation (Geen, 1990). For example, a boy who grows up in an abusive household may well learn to use physical force as a means of coping with unpleasant situations. He may learn both the "how to hit" aspects and the "why hit" aspects, especially if the modeled aggression appears to work. As an adult he may well recreate this abusive pattern in his own family. Hot temperatures contribute to the unpleasantness of many situations and could therefore trigger the expression of the learned aggressive behavior patterns.

CNA, a more recent cognitive theory, is based on network models of memory that focus on the interconnectedness of related incidents or thoughts in memory. According to CNA, thoughts, feelings, and behavioral programs are stored together in memory such that when a particular thought or feeling emerges into consciousness, related thoughts, feelings, or behavioral propensities are activated (may be experienced). Central to CNA is the role of negative affect as the initiator of hostile thoughts, feelings, and behaviors. Berkowitz states that an increase in negative affect (as occurs in uncomfortable temperatures) can *automatically* bring aggressive thoughts and recollections to mind, as well as lead to the immediate experience of angry feelings and aggressive behavioral inclinations.

Dodge and colleagues (e.g., Dodge & Crick, 1990) and Huesmann and colleagues (e.g., Huesmann, 1984; Huesmann, Eron, Lefkowitz & Walder, 1984) have similarly shown that children learn aggressive scripts and apply them in many normal situations in everyday life. These scripts also bias the interpretation of ambiguous encounters in an aggression-related way. Presumedly, these scripts are learned in a variety of ways from many sources (including television) and can be linked to a variety of nodes in memory, such as negative affect.

A General Affective Aggression Model

A theory of affective aggression (Anderson et al., 1995, 1996) incorporates assumptions of some of the aforementioned theoretical perspectives. As the various perspectives address different aspects of the generation and maintenance of aggressive behavior, from the physiological to the social, the various theories are best considered as addressing different levels of analysis. Our goal is to integrate theoretical processes at different levels in order to more fully understand the processes by which social/environmental variables (e.g, temperature) operate via aggressive cognitions, feelings, and arousal to produce aggressive behaviors.
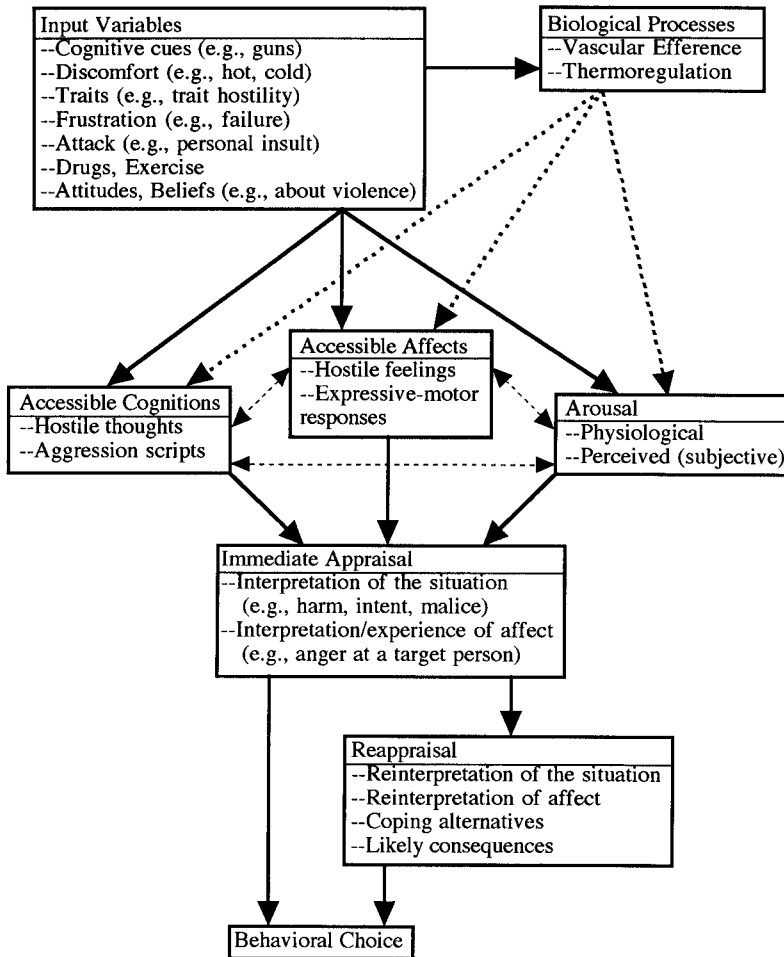
FIGURE 10.2 A general affective aggression model.

Our framework posits three main routes through which various input variables can influence aggressive behavior. Certain environmental factors (e.g., frustration) or individual differences (e.g., aggressive personality) can increase the accessibility of hostile thoughts, hostile feelings, or physiological arousal (see Figure 10.2). The automatic priming of aggressive thoughts and feelings may well come about, in part, because of the biological processes at work. For instance, Zajonc's vascular theory may account (in part or full) for increases in hostile affect in hot temperatures. Other thermoregulatory processes may also create specific aggression-related emotional and cognitive states via hormonal and neural links.

Consistent with CNA and various cognitive models, these initial priming effects may well spread to a variety of associated thoughts, feelings, scripts, and

motor programs. All this sets the stage for subsequent aggressive behavior. When in such a state, people may feel more angry and may interpret ambiguous remarks as being more hostile than they normally would. In turn, this can influence how they behave. Under the right (or wrong) circumstances, an aggressive behavior may well result, which begins a reciprocal aggression cycle with another person that can spiral out of control.

In our model, situational factors such as hot temperatures as well as individual differences such as hot temperaments (aggressive personality) operate by making aggression-related thoughts and emotions readily accessible for application to the current situation. In other words, a variety of factors can increase the person's "preparedness" to aggress. Other factors may mitigate or exacerbate the aggressive impulse and its eventual expression in behavior. Such factors may influence the initial appraisal or the reappraisal processes. For instance, learning about mitigating circumstances may decrease a person's anger at someone who has thwarted their attempts at some task and may also decrease retaliative behaviors toward that person (e.g., Dill & Anderson, 1995).

PRACTICAL SIGNIFICANCE

The third and final major issue concerns practical implications. Although many implications follow directly from the work on the temperature–aggression hypothesis, others follow from the broader theoretical context concerning affective aggression. If the temperature–aggression hypothesis is correct, what can be done to reduce unwarranted aggressive behavior in society? In what situations or contexts would an intervention be likely to work? What type of interventions are likely to produce the desired effects? These issues will be examined at the end of the chapter, after empirical and theoretical issues have been presented and discussed in detail.

EPISTEMOLOGICAL STRATEGIES

This section specifies the epistemological strategies and assumptions used in examining the temperature–aggression literature. Definitions of key concepts used throughout this chapter are also spelled out in some detail.

TRIANGULATION

Triangulation is best illustrated by the following quote by Richard Cardinal Cushing (New York Times, 1964), commenting on the propriety of calling Fidel Castro a communist, "When I see a bird that walks like a duck and swims like duck and quacks like a duck, I call that bird a duck."

In other words, one extremely valuable way of examining a proposition is to test it from several different perspectives. If the results of tests from several per-

spectives converge on the same answer, confidence grows. This approach has a variety of names such as "multiple operationism" or "triangulation" (e.g., Anderson, 1987; Campbell & Fiske, 1959; Crano & Brewer, 1973; Feigl, 1958; McGrath, Martin, & Kukla, 1982).

In the temperature–aggression domain, three major perspectives have emerged: geographic region effects, time period effects, and concomitant heat effects (Anderson, 1989). Geographic region studies examine indices of aggression in regions that differ in climate or concurrent temperature. Do hotter cities have higher violent crime rates than cooler ones, for example? Time period studies examine aggression rates in one location (e.g., in one city, or one country) but in a number of different time periods that differ in temperature. Do hotter months produce higher violent crime rates than cooler ones? Concomitant studies assess aggression and temperature at the same time (i.e., concomitantly) and at several different times in which the temperature varies. For example, do subjects randomly assigned to a hot condition behave more aggressively toward a provoking confederate than subjects assigned to a comfortable temperature? In a sense, concomitant studies are really a subset of time period studies. The advantage of assessing temperature and aggression concomitantly is sufficiently important to warrant treating it as a separate perspective. These studies are typically performed in laboratory settings, although several impressive field studies of this type have also been conducted.

The main advantage of the triangulation approach is that weaknesses of a particular type of study usually do not apply to other types. Therefore, consistency of results across different types of studies allows us to triangulate or "home in" on a true causal factor. Thus, if the temperature–aggression hypothesis is supported in studies of geographic region effects, time period effects, and concomitant temperature aggression effects, we can be fairly sure that hot temperatures do have a direct effect on aggression.

META-ANALYSIS (IN SPIRIT, IF NOT IN METHOD)

The current popularity of meta-analytic techniques is often warranted and sometimes misplaced. On the one hand, using statistical procedures to combine the effect sizes of different studies examining the same hypothesis can be revealing, especially in literatures where there is considerable diversity of results and controversy in their interpretation. On the other hand, there is an unwarranted tendency to view the traditional narrative review approach as being vague and subjective. In actuality (at least, in our view) the traditional narrative review has many of the best features of a good meta-analysis. Both collect as many of the relevant studies as can be found. Both categorize the studies on the basis of potentially relevant features, such as type of dependent variable measure used, or the environmental setting of the research. Both test hypotheses about whether the underlying effect is consistent and whether certain features tend to increase, decrease, eliminate, or reverse the effect. Indeed, some "narrative" reviews of the past have statistically combined

results from different studies to get a clearer view of the overall pattern of evidence (e.g., Anderson, 1989; Anderson, Miller, Riger, Dill, & Sedikides, 1994).

This chapter has features of traditional narrative reviews and of meta-analytic approaches. The published literature was exhaustively searched for studies relevant to the temperature–aggression hypothesis. Unpublished material was excluded both because we are not particularly interested in establishing the exact effect size and because excluding unpublished work provides some quality control. In addition, a few of the published studies were excluded because their data were reported elsewhere, data were reported in so poor a fashion that we could not determine whether they really supported or contradicted a given position, or the methods used were so poor that any conclusions based on them would be misleading at best. Where possible, results of statistically combined sets of studies are presented. In most cases, officially sanctioned meta-analytic procedures were not used, either because they were not needed or because they seemed inappropriate. In essence, a meta-analytic approach as adopted in spirit, if not always in method.

DESTRUCTIVE TESTING

"Destructive testing" is a term borrowed from structural engineering and materials science (Timoshenko, 1953; Wilson, 1984). It is best illustrated by analogy. A new metal alloy has been developed. Initial tests have shown it to be fairly strong. To find out just how strong it is, a series of destructive tests are conducted, i.e., increasing stresses are applied to a sample of the new alloy until it breaks. There is no question about whether it can be broken, only how much stress it can take before it does break.

The initial test of strength is analogous to a zero-order correlation, perhaps between the hotness of U.S. cities and their violent crime rates. It is a simple test of the basic theoretical hypothesis. Adding increasing stresses is analogous to adding various statistical controls to the regression model, such as poverty rates in various cities. The relevant question about the obtained relation between heat and aggression is not, "Can it withstand all possible attempts to reduce it to nonsignificance?" What is of interest in destructive testing is how much stress the target relation can withstand. The ultimate judgment concerning the strength of the target relation (here, temperature and violent crime rate) is somewhat subjective and will therefore differ from scholar to scholar. However, there are reasonable rules of thumb that all scholars can apply. For instance, control variables with good theoretical grounding are more appropriate and more informative than post hoc variables of dubious relevance.

Destructive testing is a hybrid of the traditional "theory centered" approach to science, in which hypotheses are derived from a formal theory and then tested, and the "result centered" approach advocated by Greenwald, Pratkanis, Leippe, and Baumgardner (1986), in which one asks, "Under what conditions does x lead to y?" rather than "Does x lead to y?" This approach was applied in evaluating the

current temperature–aggression hypothesis literature (for a more detailed presentation of destructive testing, see Anderson & Anderson, 1996).

DEFINITIONS

Some of the controversy in the temperature–aggression hypothesis literature stems from ambiguous definitions of key concepts. Definitions for several concepts are provided to reduce this problem.

Aggression, Affective Aggression, and Violence

"Aggression," "affective aggression," and "violence" are used interchangeably in this chapter, with the only distinction being that violence is restricted to the most extreme types of aggressive behavior. Our definition includes three components. First, these terms refer to behavioral acts, not to thoughts or feelings. We explicitly specify when we mean "aggressive cognitions" or "aggressive feelings." Second, the primary intent of these acts is to harm the victim. Third, there is a large anger/hostility component in the acts.

Some behaviors typically classified as violent do not meet this definition. For instance, robbery is classified by the FBI as a violent crime. However, in our view the primary intent in most robberies is not to harm the target, it is to gain some economic benefit. Thus, because of the motive ambiguity, robbery is not included as a measure of aggression or violence.

Another somewhat ambiguous case is rape. Although it is clear that rape is violent in its consequences to the victim, there is some debate about what portion of rapes are perpetrated with harm as the primary intent (e.g., Felson, 1993). We believe that a significant portion of rapes are intended to harm the victim, and that anger or hostility toward the victim is a part of many rapes. Thus, rape is included as a measure of aggression/violence. However, because of the mixed motives involved, one might expect weaker relationships between rape and aggression-instigating variables than between more purely aggressive acts (e.g., assault) and aggression-instigating variables. In sum, our definition of aggression includes most acts that typically have been labeled as spontaneous aggression, pain-induced aggression, and affective aggression.

Temperature Aggression Hypothesis vs Heat Effect

The *temperature aggression hypothesis* refers to the theoretical statement that uncomfortable temperatures cause increases in aggressive motivation and (under the right conditions) in aggressive behavior, and that they do so in a direct fashion. In most cases the temperature–aggression hypothesis refers to the "hot" side of this relation. On occasion, however, it also refers to the "cold" temperature side. As noted in earlier works (e.g., Anderson & Anderson, 1996), any theoretical hypothesis is protected from disconfirmation by multiple translation layers; the more abstract the theory, the more translation layers are necessary to get to the specific empirical realizations that can be subjected to testing.

The *heat effect* refers to an empirical observation that hot temperatures are positively associated with increased aggressive behavior. It is, essentially, a brief description of a specific type of empirical relation.

With these epistemological and definitional issues in hand, we now turn to the empirical literature. When possible, we will summarize findings presented in Anderson (1989). Newer results will be presented in greater detail.

GEOGRAPHIC REGION

Anderson's earlier reviews (1989; Anderson & DeNeve, 1992) revealed amazing levels of consistency in geographic region effects across countries and eras. Hotter locations have higher violent crime rates than cooler locations within the same country.

EARLY STUDIES

Some of the early studies of the temperature–aggression hypothesis do not present data in sufficient detail to allow statistical analysis. Nonetheless, the results are impressive in their consistency. For instance, Guerry (cited in Brearley, 1932) reported that in the years 1826–1830 crimes against people (e.g., assault) were twice as prevalent in southern France as in central or northern France, whereas crimes against property (e.g., burglary) were twice as prevalent in the north. Similarly, Lombroso (1911) reported that the homicide rate in the south of England was almost 10 times that of northern England.

Other studies did allow some form of statistical analysis. Lombroso (1911) reported several aggressive crime rates by degrees latitude of the region for both Spain and Italy. In both countries, of course, latitude is essentially a proxy measure of average temperature. Anderson (1989) found that in Lombroso's data violent crime rates correlated significantly and positively with latitude in both countries. Brearly (1932) reported the state-level homicide rates in the United States during the 1918–1929 time period. Anderson (1989) showed that in Brearly's data "the southern states had dramatically higher homicide rates ($M = 19.37$ per 100,000) than did the northern states [$M = 3.55$, $t(16) = 7.93$, $p < .001$"] (p. 79).

MODERN ERA STUDIES

None of the early studies included controls for other variables such as poverty rate, other than by restricting aggression rate comparisons to within country comparisons. Several modern era studies similarly focused primarily on the heat effect with minimal attention to possible third-variable controls. Lester (1986) compared the homicide rates of the 45 largest standard metropolitan statistical areas (SMSAs, i.e., cities) in the United States in 1970. Predictor variables included average temperature and precipitation (30-year averages), latitude, and longitude. Of

most relevance here was the finding that temperature was strongly correlated with the homicide rate ($r = .54$, $p < .001$).

Two studies compared aggression rates as a function of climate across countries and cultures. The one by Robbins, DeWalt, and Pelto (1972) included measures of behavior that would meet our definition of aggression (homicide) as well as one that is less clearly an example of affective aggression (incidence of warfare). They found a significant positive relation between temperature and homicide ($p < .01$), but no relation with warfare. Schwartz (1968) similarly found no relation among the temperatures of 51 countries and frequency of political violence. In other words, the heat effect is by and large restricted to what we have termed affective aggression. More planful violence, such as wars and revolutions, does not appear to be related to temperature.

Other studies in the modern era have included various types of socioeconomic and social controls. deFronzo's (1984) study of crime rates in 142 SMSAs in the United States in 1970 included such controls. Although the results provided support for the temperature–aggression hypothesis at the level of zero-order correlations, statistical analysis shortcomings preclude any firm judgments about the strength of the heat effect when socioeconomic factors are controlled (for more details, see Anderson, 1989). Rosenfeld (1986) included some socioeconomic factors in two studies of crime rates in U.S. cities in 1970 and found significant region effects. Southern cities were especially higher than northern ones on murder and assault. Other region studies (Rotton, 1986; Rotton, Barry, & Kimble, 1985) have also found support for the temperature–aggression hypothesis, despite some conceptual and statistical ambiguities (for more details, see Anderson, 1989). The most extensive geographic region study is one on 1980 crime rates in 260 SMSAs (Anderson, 1987). That study included 14 "social" variables for each city such as unemployment, per capita income, education, age, and racial composition. The results were that hotter cities had higher violent crime rates even when other social variables were statistically controlled.

More recently, Anderson and Anderson (1996) recreated this data set with several modifications. The most important addition was a "southern culture of violence" index for each city. White arrest rate data were also gathered for these same cities in 1980, in response to Nisbett's (1993) suggestions that his "culture of honor" thesis can explain the higher incidence of violent crime in the south and that only white perpetrator data are relevant. The specific procedures and results are described in the following section.

Violent Crime Rates in U.S. Cities

Aggression

Two measures of violent crime were constructed. The first was a z-score composite of overall murder, rape, and assault rates. The second was a z-score composite of murder, rape, and assault arrest rates for the white population, as suggested by Nisbett's work.

Southernness

Each city's southernness was indexed by converting three indicators to z scores and summing them. One indicator was a simple south–nonsouth distinction based on U.S. Census Bureau classifications. Cities in southern states were assigned a score of 1, whereas nonsouth cities were given a score of 0. The second indicator was Gastil's (1971) southernness index, based on migration patterns from the old south. The third indicator was the percentage of voters who voted for George Wallace in the 1968 presidential election (Scammon, 1970). Preliminary analyses revealed that this SCV index was linearly and curvilinearly related to violent crime. We therefore converted the SCV index score to z scores and then created a quadratic term (SCV^2). This procedure allowed us to examine the linear SCV effect on violent crime independently of the curvilinear component.

Temperature

The hotness of each city was assessed with a four-item summed index of z scores. The items were (1) number of hot days ($\geq 32.2°C$, 90°F), (2) number of cold days ($\leq 0°C$, 32°F), (3) cooling degree days (amount of cooling needed to maintain a comfortable base temperature of 18.3°C, 65°F), and (4) heating degree days (amount of heating needed to maintain a comfortable base temperature of 18.3°C, 65°F). The number of cold days and heating degree days were multiplied by -1 so that larger scores meant warmer temperatures on all indicators.

Social Variables

The 12 social variables used were unemployment rate, per capita income, poverty rate, mobility (percentage living in a different home in 1975), high school education (percentage of the ≥ 25-year-old population that had graduated), college education (percentage of the ≥ 25-year-old population that had attended 4 or more years), population size, percentage Black, percentage Spanish, percentage less than 18 years old, percentage 18–64 years old, and median age.

Results: Heat Effect on Violence

Figure 10.3 presents the results from several regression analyses on the heat effect on violence. As can be seen, regardless of whether we examine overall crime rates, or the white arrest rate for violent crime, temperature significantly predicts violence rate differences in major U.S. cities. This is true even when all 12 social variables and the southernness index are partialled out first.

Results: Southernness Effect on Violence

Figure 10.4 presents the parallel results when the southernness index is the predictor of interest. As can be seen in Figure 10.4, the linear correlations between the southernness index and both violence measures are positive and statistically significant when the only other predictor in the model is the curvilinear term. However, controlling for temperature and other predictor variables eliminates the linear southernness effect on overall violent crime rate and appears to reverse its effect on the white arrest rate for violent crime.
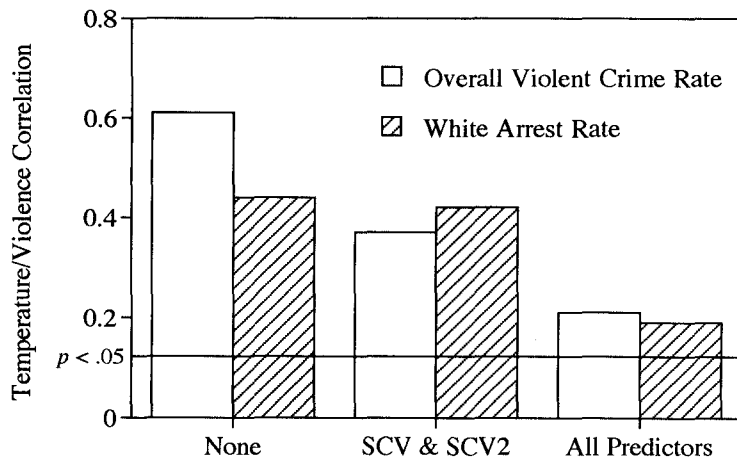
Variable(s) Partialled from the Temperature/Violence Relation

FIGURE 10.3   Zero-order and partial correlations between temperature and violence.
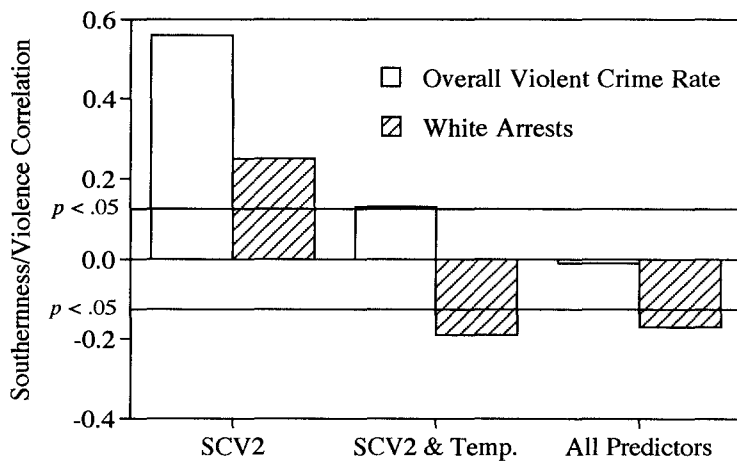
Variable(s) Partialled from the Linear SCV/Violence Relation

FIGURE 10.4   Partial correlations between southernness (SCV) and violence.

Results: Latent Variable Analysis

In the preceding regression analyses, all 12 social variables were used. A look at the list of variables reveals some redundancy in them. For instance, there are several measures of average wealth or poverty. To get a better picture of the relationship between temperature and the violent crime rate, a number of latent
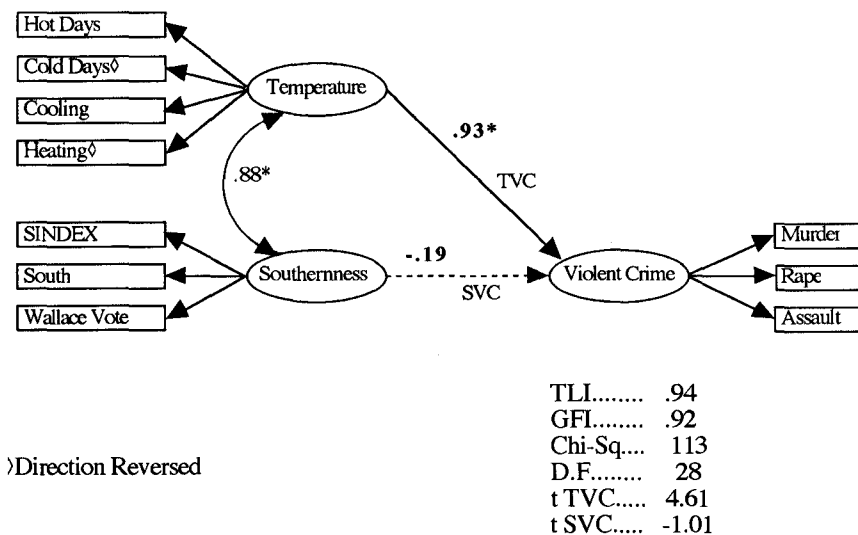
FIGURE 10.5   Latent variable model of temperature and southernness effects on violent crime.

variable models were tested. Getting a model with a good overall fit and without serious statistical shortcomings proved to be a difficult task. Figure 10.5 presents a simple model that includes only violence, temperature, and southernness variables.[2] As can be seen from Figure 10.5, the overall fit was quite good according to the Tucker–Lewis index, the goodness-of-fit index, and the ratio of χ^2 to degrees of freedom (Church & Burke, 1994; Marsh, Balla, & McDonald, 1988; Marsh & Hocevar, 1985). Figure 10.5 also shows that the latent temperature factor is significantly related to the violent crime latent factor, whereas southernness is not. Indeed, the southernness relation to violent crime is even in the wrong direction.

Figure 10.6 adds the three social variables that produced the best fit, given theoretical constraints. The percentage of the city population that was classified as Black or Spanish (Census Bureau designations) and the poverty rate combined to produce a latent factor called low socioeconomic status (SES). Population size also proved to be a valuable predictor of violent crime rate, but it did not form a meaningful latent factor. The results of this analysis were very similar to the model that did not include any of the social variables. The various fit indices all yielded acceptable fits. The latent temperature factor was significantly related to the latent violent crime factor. Southernness was related to violent crime in the direction predicted by the southern culture of violence model, but not significantly so ($t < 1$). In addition, the low SES latent factor was positively related to violent crime. Cities

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[2]Error terms and correlations among error terms in the final model are not displayed in Figures 10.5 and 10.6 to simplify the picture. We tested identical models with a quadratic southernness measure as well. The basic results shown in Figures 10.5 and 10.6 were replicated, but there were statistical shortcomings that led us to prefer the displayed models.
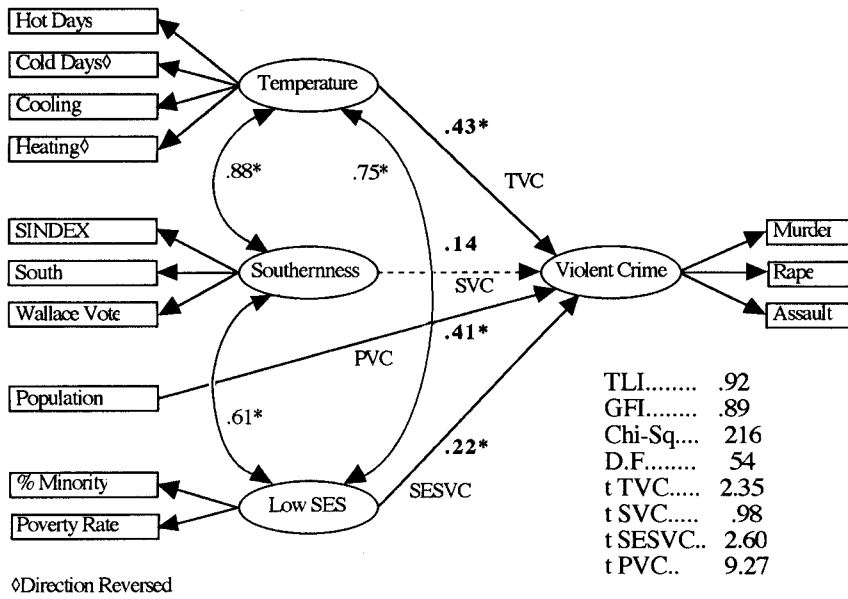
FIGURE 10.6 Latent variable model of temperature and southernness effects on violent crime, with three social variables.

with large, poor, minority populations had higher violent crime rates. Finally, population size was positively related to violent crime rates, even though this data set (restricted to SMSAs) contains only fairly large metropolitan areas.

SUMMARY OF GEOGRAPHIC REGION STUDIES

Across a wide range of years and countries, the geographic region studies produce a highly consistent picture of heat effects. Hotter regions in the United States and in several western European countries have higher violent crime rates than cooler regions. The more recent studies that have included statistical controls for various possible confounds and indirect effects show that the heat effect in region studies cannot be easily dismissed as artifactual.

Of course, by themselves these studies do not rule out all possible indirect effects. For instance, it is possible that better measures of southern culture of violence would yield somewhat different results. For example, it is possible that an attitude/value measure of adherence to the culture of honor, administered to a representative sample of residents of each city, would eliminate the heat effect when partialled out statistically. In other words, it could be that hot locations have tended to produce cultures of honor in which high violence is a part of being well socialized. If true, this temperature/culture of honor relationship would then need explaining. As noted elsewhere (Anderson & Anderson, 1996), the temperature–aggression hypothesis could easily handle such a state of affairs. If hot temperatures do tend to increase

aggressive behaviors, cultures that develop and evolve in hot climates would tend to develop rationales (or rationalizations) for violent acts committed by its high status citizens. In other words, direct heat effects could, over time, lead to the development of a set of attitudes and values that encourage violence, at least under certain "honorable" conditions.

Several theories remain plausible as explanations for the obtained heat effect in these region studies. Routine activity theory could be playing a role, although certain versions of it cannot account for the findings. Perhaps the typical "routine" activities of people in warmer climates are those that promote aggressive behaviors. There may be more intermingling of people in general, increasing the potential for conflict and violence.

Although data argue against a strong version of southern culture of honor theory—the version that says all region-based heat effects are due to SCV and none are due to direct heat effects—a weaker version seems plausible and is not completely ruled out by extant findings. There may well be a southern culture of violence that has developed in the U.S. south, and it may continue to increase violence independently of direct heat effects. Nisbett's preliminary studies on his version of culture of honor (e.g., Nisbett, 1993) are quite interesting in this regard.

The general model of affective aggression is more strongly supported by these region data than are other theories. The temperature–aggression hypothesis aspect of the general model has survived a number of possible disconfirmations, and thus gains strength.

TIME PERIOD

Time period studies examine aggression rates across time periods that differ in temperature. Many such studies have been conducted using time periods of various lengths, with the unit of analysis being as short as a day or as long as a year. Because humans are skilled at carrying grudges and recreating earlier emotional states, time periods of less than 1 day are probably inappropriate except for studies in which the target aggressive behaviors can be carried out by the subject almost immediately. (Most laboratory studies of aggression have this characteristic, for example.) Anderson (1989) presents a detailed summary of many time period studies. This section mentions those studies briefly and focuses on more recent studies.

HOT DAYS

Anderson (1989) analyzed Dexter's (1899) New York City assault data and found both linear and curvilinear effects of temperature on the relative frequency of assaults (both $ps < .001$). The specific form of this relation was that at cool temperatures, slight increases in temperature had only a small impact on assault, whereas at uncomfortably warm temperatures, further increases in temperature

yielded relatively large increases in assaults. Carlsmith and Anderson's (1979) study of riots in the United States in 1967–1971, Harries and Stadler's (1988) study of assault in Dallas, Rotton's (1982) study of rape in Dayton, Rotton and Frey's (1985) study of assaults and family disturbances in Dayton, Cotton's (1986) studies of violent crime in Des Moines and in Indianapolis, and Anderson and Anderson's (1984) studies of violent crime in Chicago and in Houston all produced similar findings of maximum aggression in the highest temperature ranges. Interestingly, several of these studies also examined heat effects on less aggressive crimes such as burglary. The heat effects were consistently weaker for these "less violent" crimes (Anderson & Anderson, 1984; Cotton, 1986).

More recent studies add to the consistency of the heat effect in daily time period studies. Three studies have used calls to police departments as criterion variables. LeBeau and Langworthy (1986) studied the frequency of "calls for service" to the Chicago Police Department during 1976–1979. They found (among other interesting effects) that temperature was the best predictor. As temperature went up, so did the frequency of calls. However, because calls for service include calls for relatively nonaggressive problems as well as aggression-related ones, the results must be interpreted with caution.

Walters (1991) examined temperature and pollen counts as predictors of frequency of 911 calls to the Kansas City, Kansas, police department in the years 1986–1989 from March 1 through October 31 in each year. Data for each year were broken down into three time periods: March 1–May 24, May 25–August 14, and August 15–October 31. Results were reported in the form of correlations in each time period in each of the 4 years. The temperature/police call correlations were averaged for each time period across years. For each time period the average temperature/police call correlation was significant (all p values $< .01$), $r = .57$, $r = .18$, and $r = .49$, for the first, second, and third time periods, respectively. Even though each was significant, it is obvious that the lowest correlations occurred in the second time period. We suspect that this is due to a relatively smaller range (or standard deviation) of temperatures in that late spring/early summer time period, although we cannot be certain of this. It is also interesting to note that partialling out the pollen count factor did not appreciably affect the temperature/police call correlations. Once again, these data support the temperature–aggression hypothesis, but caution in interpretation is warranted because not all 911 calls involve affective aggression. (Walters reports that about 85% of these calls are for police assistance of some kind.)

Another interesting study of the heat effect in daily time periods is Reifman, Larrick, and Fein's (1991) study of aggression in major league baseball. The criterion variable was the number of players hit by a pitch (HBP) in the 1986–1988 seasons. A regression analysis of the heat effect included statistical controls for walks, wild pitches, passed balls, errors, home runs, and attendance. The heat effect was still significant ($p < .002$), with relatively more HBPs in games played on hotter days. Other control procedures were used to rule out the possibility that some teams whose home games were played in hot climates were simply more

likely to have high HBPs regardless of temperature. Finally, in a replication study, data from the 1962 season showed essentially the same heat effect correlation.

Cohn (1993) examined weather and temporal variables as predictors of police calls for service for rape and for domestic violence in Minneapolis for the years 1985, 1987, and 1988. Although the results are complex and occasionally difficult to interpret, the main findings of relevance to this chapter are (a) temperature was strongly related to both types of violence (p values < .001), (b) higher temperatures yielded higher violence rates, and (c) rape was less predictable by the whole set of variables than was domestic violence. Cohn (1993) discussed several possible reasons for the weaker results on the rape measure. Of particular interest is her discussion of other work showing that a significant portion of rapes are planned. This suggests, as noted earlier, that rape may well be a less pure exemplar of spontaneous affective aggression and thus should be examined separately from purer acts of affective aggression such as assault and murder. One alternative explanation of the weaker results for rape concerns the incidence rate. Domestic violence calls were about 40 times as frequent as rape calls, which would tend to make the domestic violence measure less susceptible to random fluctuations in frequency than rape.[3]

Cohn and Rotton (1997) conducted a time series analysis of the reported assaults in Minneapolis in 1987 and 1988 as a function of time of day, day of week, month, and temperature. (Many other "control" variables were also included, but are not particularly relevant to this chapter.) The study was performed to test (a) the NAE-inverted U shape prediction of the temperature–aggression relation and (b) the RAT assumption that time of day moderates the relation between temperature and assault rates. The authors found significant positive relations between temperature and assault for every time period (in 3-hr intervals) except between 6:00 and 11:59 a.m. This complex data set contains many other interesting results. For instance, evidence shows that time of day and day of week moderate the effects of temperature on assault. This is entirely consistent with any model of aggression: opportunities are needed to aggress, and opportunities vary by day of week and time of day.

One of the main conclusions of the article—that there was a significant downturn in assault as temperatures became hot—is simply not borne out by the re-

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[3]Cohn's regression approach included linear, quadratic, and cubic terms, represented by the raw temperature (T), raw temperature squared (T^2), and raw temperature cubed (T^3). In some analyses the squared and cubed terms were kept without all of the lower order terms. This creates some difficult interpretation problems because the higher order terms are necessarily highly confounded with the lower order terms unless raw data are first converted to deviation score form. Thus, the finding that only the T^2 term yielded a significant effect in the 1985/1987 domestic violence model (Cohn's Table 7) could be misinterpreted as meaning that only a curvilinear effect occurred. However, plotting a line using the T^2 beta and T^2 scores (e.g., 40° becomes 1600, 50° becomes 2500 . . .) and then converting the x axis back to linear temperature produces the heat effect curve frequently found in this literature. At low temperatures, there were little increases in domestic violence rates with small increases in temperature, but at uncomfortably warm temperatures, further increases produced large increases in domestic violence. This is actually both a linear and a quadratic effect. Similar interpretational ambiguities exist with the 1985/1987 rape model, which included T and T^3, but not T^2.
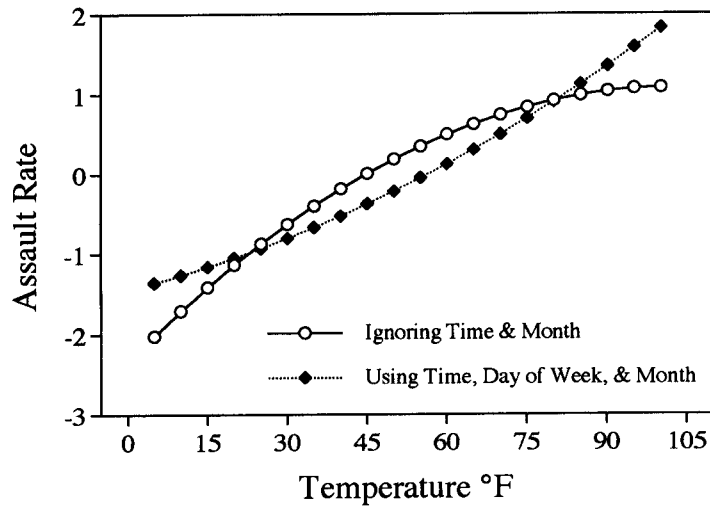
FIGURE 10.7   Relationship between temperature and standardized assault rate in Minneapolis (1987–1988). Slopes were derived from Cohn and Rotton (1997).

ported results. Conceptual, methodological, and statistical problems with this study take us well beyond this chapter (for a more thorough critique, see Bushman, Anderson, & Anderson, 1998). Two of these problems are particularly important.

The first problem concerns interpretation of the results reported in the article. Most results actually showed a clear linear relationship between temperature and assault rates, but little evidence of a downturn in assault at higher temperatures. For example, in the 56 day of week (7) × time of day (eight 3-hr blocks) analyses the linear temperature term was positively ($p < .05$) related to assault 29 times. However, the curvilinear temperature term yielded a statistically significant effect in only 10 cases, and in 7 of those the slope was positive, indicating that at hotter temperatures assault rates increased more rapidly with further temperature increases. These findings clearly contradict Cohn and Rotton's (1997) paramount conclusion that the shape of the temperature–assault relation is an inverted U; they also exemplify how overaggregation of data is problematic when analyses reveal interesting differences in effects at more microscopic levels of analysis. If the analyses that purported to show important day of week and time of day effects are accurate, then the best way to estimate the overall (or average) relationship between temperature and assault rate is to average the linear and curvilinear (quadratic) slopes across the 56 day of week (7) × time of day (eight 3-hr blocks) sets and plot the resulting equation. These averages are computed and the resulting regression line (with the diamonds) is plotted in Figure 10.7. This line shows that not only did assault rates continue to climb at the hottest of normal temperatures, but they increased at a faster rate. This is because the average curvilinear slope was positive. Even this regression line may underestimate the true heat effect because of other temperature-related "control" variables in the statistical model.

The second problem concerns the use of temperature-related "control" variables. Statistically controlling for the month of the year may have artificially reduced the effect of the linear temperature term on assault. Because month is highly correlated with temperature, removing the variance (in the assault rate) that is associated with month effects may remove much of the variance that is truly part of the temperature effect. Although Cohn and Rotton (1997) claim that removing month from the statistical model produced little change, it did in fact significantly change the shape of the temperature–assault curve. A model with month statistically controlled yielded linear and curvilinear slopes (+.0337 and –.0006, respectively) that produce a major decline in assault rates beginning at about 77°F. However, a model that differed only in the removal of month as a control variable yielded slopes that produce continued increases in assault rates through 100°F. The line with the circles in Figure 10.7 displays this latter temperature effect on assault. Other "control" variables in various models (including both models in Figure 10.7) may also have artificially deflated the statistical estimate of the linear temperature term as well. Furthermore, these two models (with and without month as a control variable) further suffer from the over-aggregation problem outlined in the preceding paragraph.

In sum, although both of the lines in Figure 10.7 already contradict the main conclusions of Cohn and Rotton (1997), there is reason to believe that statistical models that produced these lines inappropriately reduce the estimated increases in assault rates at high temperatures. The "diamond" line in Figure 10.7 is based on a statistical model that uses inappropriate temperature-related control variables. The "circle" line is based on a model that overaggregates across time and day of the week.

Other problems also warrant attention. Minneapolis is an inappropriate city to sample when testing linear and curvilinear temperature effects because the NAE downturn is posited to begin in the mid-eighties. Minneapolis reaches truly hot temperatures far less often than do southern cities, and there may well have been too few time periods with truly hot temperatures to accurately test for a hot downturn in assault. Furthermore, use of assault reporting rates is problematic when studying time of day effects because assault reports may frequently occur well after the crime has been committed. Also, heat stress may have a cumulative effect over time that is expressed later, sometimes during somewhat cooler periods of time. The point is that although the Cohn and Rotton data are useful for some purposes (e.g., testing whether there are general day of week or time of day effects, or testing the general heat hypothesis that hotter temperatures are generally related to violence), such field data are not very useful for testing specific hypotheses involving the exact shape of the temperature–aggression relationship. Thus, they cannot precisely test the NAE predicted downturn in aggression at about 85° versus a simple negative affect model predicting continued increases in violence through the normal temperature range (i.e., about 98°F).

In sum, the Cohn and Rotton (1997) results appear largely inconsistent with the NAE model and consistent with a model in which aggressive tendencies continue to increase throughout the normal temperature range. However, as noted earlier,

studies of reported crime rates do not appropriately test the exact shape of the temperature–aggression relationship. More accurate tests of shape may be conducted in laboratory settings where the time and temperature of the instigation to aggress are known or in field studies that similarly assess instigation, temperature, and aggression concomitantly (e.g., Kenrick & MacFarlane, 1984; Reifman et al., 1991). As noted in other works and later in this chapter, we believe that under certain conditions a downturn at moderately uncomfortable temperatures may well occur.

HOT MONTHS

Murder

Anderson (1989) combined monthly murder rate percentages in the United States across studies by Brearley (1932), Cohen (1941), Iskrant and Joliet (1968), Lester (1979), and Michael and Zumpe (1983). An analysis of variance on these monthly percentages yielded a significant month effect ($p < .001$). The peak murder months were July and August, followed closely by December. The high December rate appears to be due to routine activities involved with Christmas, which often involve excessive alcohol consumption.

Assault

A combined analysis of monthly assault rate patterns in the United States was presented in Anderson (1989). The seven data sets came from Aschaffenburg (1903/1913), Cohen (1941), Dexter (1899), Dodge and Lentzner (1980), Michael and Zumpe (1983), and Perry and Simpson (1987). The result, displayed in Figure 10.8, was a significant month effect ($p < .001$) with a peak in the hot summer months.
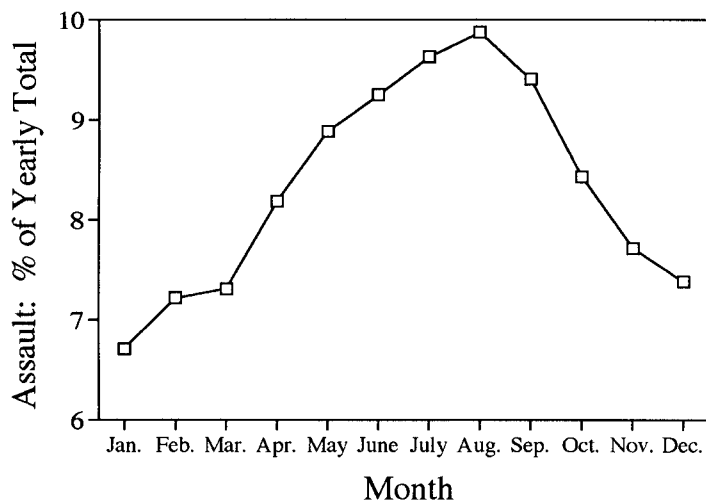
FIGURE 10.8   Monthly distribution of assaults. Adapted from Anderson (1989).

Rape

Monthly rape patterns were also examined in detail by Anderson (1989). The data sets were taken from Amir (1971), Aschaffenburg (1903/1913), Hayman, Lanza, Fuentes, and Algor (1972), Lombroso (1899/1911), Michael and Zumpe (1983), and Perry and Simpson (1987). There were eight data sets from four countries (England, France, Germany, and the United States) in these sources. An ANOVA yielded a significant month effect that paralleled the assault results, with the most rapes occurring in the hot summer months ($p < .001$).

Spouse Abuse

Several other monthly studies are reviewed in Anderson (1989), with the same general finding that aggression peaks in summer months. One of these studies deserves special mention because its findings relate to several alternative hypotheses. Some critics have suggested that assaults and rapes occur more frequently in the warmer months because of more frequent contact among potential victims and perpetrators (i.e., people get out more in the summer) and because of "women's scantier clothing" being provocative. Michael and Zumpe (1986) reasoned that if these alternative explanations were true, then wife battering should not show the typical summer increase. One could even argue that wife battering should go down, as the increase in "getting out" should decrease the time and opportunity for wife battering. If aggression is directly temperature related, though, the same summer increase observed for other violent crimes should be obtained with spouse abuse.

Michael and Zumpe (1986) examined crisis calls to 23 different women's shelter organizations in five locations during 1981–1984 (at least 2 consecutive years of data from each location). In each location the annual rhythm maximum occurred in either July or August ($p < .025$). In each case the pattern of monthly abuse means corresponded very closely to monthly temperature means. Michael and Zumpe (1986) further noted that ". . . the maxima for wife abuse in Atlanta and Texas occurred about 40 days earlier in the year than those in Oregon and California; this difference in timing corresponded (within a few days) to the differences in the rape maxima in these states, which correlated with the times of the local temperature maxima" (p. 640). Finally, they noted that the photoperiod maxima (the maximum amount of daylight, another alternative to the temperature interpretation) in these locations did not show this 40-day difference.

These data do not rule out the possibility that some type of routine activity effect also occurs independently of temperature, but they do show that the routine activity theory (or women's scantier clothing, or photoperiod shifts) cannot account for the summer increase in wife battering. Michael and Zumpe imply that it is more parsimonious to ascribe monthly effects on a variety of aggressive behaviors to the same causal factor, i.e., the direct heat effect, than to adopt different (and largely untested) explanations for different forms of affective aggression. We agree.

New Monthly Studies

A number of studies using month as the target time period have provided additional support. This section begins, however, with a study that at first appears to

support the temperature–aggression hypothesis, but is actually irrelevant to it. Field (1992) reported a sophisticated time series analysis of 40 years of crime data in England and Wales, primarily as a test of routine activity theory. Field reasoned that many types of crime, including nonviolent property crimes, should be more prevalent when people are out of their homes. He further proposed that people should be out of their homes more often when the weather is nice, *relative to normal weather patterns*. He thus adjusted all the raw data for seasonal effects, i.e., monthly crime data as well as weather data were seasonally adjusted prior to the main regression analyses. The main finding was that *seasonally adjusted temperature* was a significant predictor of *seasonally adjusted crime* rates for violent crimes, sexual offenses, burglary, theft, and criminal damage, but not for robbery. On the whole, these data support routine activity theory, although the lack of an effect on robbery is problematic, as is the failure of rainfall to predict crime rates. However, these analyses are irrelevant to the temperature–aggression hypothesis, as noted by Field. The seasonal adjustment procedure essentially "adjusts out" most (or all) of the direct heat effects. Monthly crime patterns may well be influenced by both routine activities and more direct heat effects. "It is entirely possible that temperature affects the level of crime both through a direct [effect] on aggression and through the mediation of social behaviour" (Field, 1992, p. 348). Field (1992) also noted that many temperature findings, such as the Michael and Zumpe (1986) wife-battering study, ". . . (are) obviously not easily explicable in terms of routine activities" (p. 349).

A similar study, which involved time series analysis (Landau & Fridman, 1993), tested seasonal fluctuations in monthly robbery and homicide rates in Israel between January 1977 and February 1985. Landau and Fridman found an increase in robbery rates during winter months (November–February) that they explained with the routine activity explanation that cost of living increases in the winter months, which leads to stealing. A seasonal effect was not found for homicide, however. Homicides were highest in August, with March, May, and December following in frequency. Landau and Fridman state that the lack of a seasonality effect on the homicide findings contradicts the temperature–aggression hypothesis and that the strong August homicide effect is due to an increase in social interaction in that month. As Landau and Fridman note, the lack of an effect of the other summer months (June and July) on homicide does not support this routine activity theory. One additional problem with this study is that the total number of homicides in such a relatively small population is so small that monthly rates are likely to be quite unstable. Thus, it is probably wise to draw no conclusions from this one study.

Several studies, including one by Haertzen, Buxton, Covi, and Richards (1993), have examined monthly variations in aggressive behaviors by prison inmates. Haertzen et al. (1993) examined the frequency of "rule infractions" among prisoners in a Maryland correctional institution from July 1987 to March 1991. Seasonal as well as month-based analyses were reported. They found a weak correlation between average monthly temperature and relative frequency of rule infractions ($r = .25$, $N = 45$, $p < .10$). However, because rule infractions include

many nonaggressive violations (about 50% according to the authors), these data do not provide a clean test of the temperature–aggression hypothesis. The authors correctly noted that to study more specific and purely aggressive incidents, a larger sample of prisons over more years would be needed.

Other (earlier) studies of prisoner aggression suffer similar problems of ambiguity of aggression measures, relative infrequency of the target behaviors, and short time spans. Ganjavi, Schell, and Cachon (1985) studied the effects of several weather and geomagnetic factors on monthly rates of major violence (e.g., murder, assault) and minor violence (minor assault, suicide, self-injury) in six Canadian prisons from January 1980 to December 1983. The major violence rate was too rare to be of value. One of the prisons was for psychiatric inmates; its rate of minor violence was too low to be useful. The biggest problem from the standpoint of testing the temperature–aggression hypothesis was the inclusion of suicide and self-injury. Apparently, minor assaults were also quite rare. For these reasons, this study was not included in Anderson (1989) and is uninformative for this chapter as well.

Pettigrew (1985) examined monthly rates of simple fighting, aggravated fighting (with a weapon or accomplice), and self-mutilation in five Louisiana prisons from 1972 to 1982. Aggravated fighting is too rare to provide appropriate tests of the temperature–aggression hypothesis, and self-mutilation is not an affective aggression act as we have defined it. The simple fighting rate measure did correlate significantly with monthly average temperature ($r = .214$, $N = 180$, $p < .05$). Similarly, an analysis of variance on the monthly rates of simple fighting showed a significant month effect, with the July rate being significantly higher ($p < .05$) than every other month except June and August. However, the author pointed out that many prisoners seemed to get into minor scrapes intentionally during the hot summer months in order to be "punished" in a way that gets them out of summer field labor. Self-mutilation rates were similarly affected by temperature and a desire to avoid field labor. As a result, these data cannot be seen as adequate tests of the temperature–aggression hypothesis.

Finally, Linkowski, Martin, and DeMaertelaer (1992) reported a study of monthly rates of violent and nonviolent causes of death in Belgium over a 5-year period. Although there appeared to be some support for the temperature–aggression hypothesis—accidental violent death rates correlated positively and significantly with temperature for both men and women—ambiguities in the meaning of the different death rate categories and in the reported data analyses make firm conclusions very risky.

SEASONS/QUARTERS

Anderson (1989) presented considerable evidence (via reanalyses, in many cases) that aggressive behaviors occur more frequently in the summer (or third quarter) than in other times of the year. Data include a variety of types of violence: simple and aggravated assaults, uprisings, family disturbances, rape, and murder.
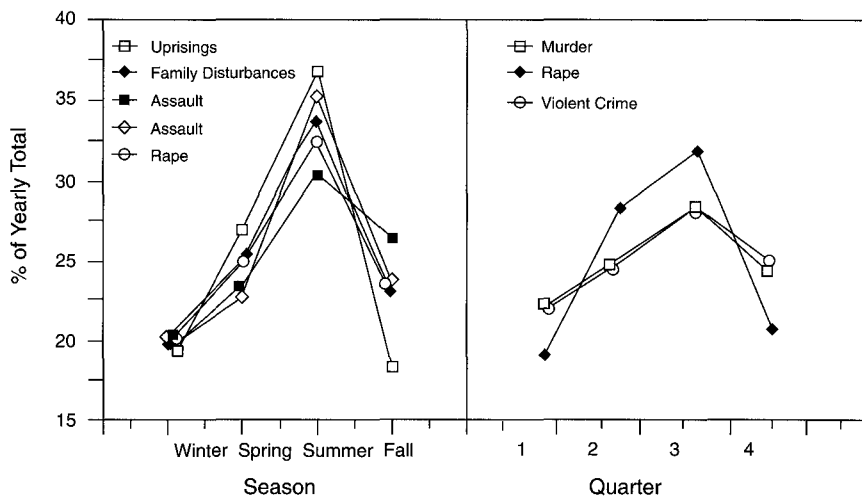
FIGURE 10.9   Quarterly and seasonal distribution of aggressive behavior. Adapted from Anderson (1989).

Data come from a variety of researchers (Anderson, 1987; Chang, 1972; Leffing-well, 1982; Lombroso, 1899/1911; Rotton & Frey, 1985), a variety of countries (e.g., England, Wales, the United States, Spain, others), and a variety of centuries (18th, 19th, and 20th). Figure 10.9 graphically summarizes these results.

Two additional studies of the temperature–aggression hypothesis with a seasonal methodology were intentionally left out of Anderson's (1989) review because of methodological problems. Both provide some support for the temperature–aggression hypothesis. Atlas (1984) studied assault rates in four Florida prisons. As noted by Anderson and DeNeve (1992), interpretational problems arise in this study because "some of the prisons had air conditioning in some places. The frequency of aggressive behaviors varied greatly from institution to institution. The number of hot, moderate, and cool days at each institution is not known" (p. 349). In addition, there did not appear to be any attempt to control for differing numbers of inmates in different months. Nonetheless, a simple reanalysis in which assaults were (a) totaled across the prisons, (b) converted to assault rates (per day), and (c) subjected to an ANOVA by quarter of the year (with three replications per quarter) produced a significant quarter effect [$F(3, 8) = 9.35$, p < .01]. The summer quarter (July, August, September) had the highest assault rate (M = 3.02, 3.20, 3.76, and 2.84 assaults per day for the first, second, third and fourth quarters, respectively). The methodological problems are severe, however, so we advise extreme caution in interpreting these particular results.

The second problematic seasonal study is the Pettigrew (1985) study of Louisiana prisons described earlier. The same interpretational problems that existed with monthly analyses also existed with seasonal ones. For the record though,

Pettigrew did find a significant increase in simple fighting among inmates in the summer ($p < .05$).[4]

YEARS

The first published study of the effect of hotter versus cooler years is a small-scale study by Anderson (1987) of violent crime rates in the United States over a 10-year period. This study found that hotter years were associated with higher violent crime rates.

More recently, Anderson, Bushman, and Groom (1997) have improved upon that earlier study in several ways in two new studies. Study 1 used time series regression procedures to test the effects of yearly average temperature and of age distribution on violent crime in the United States from 1950 to 1995. As expected, a significant ($p < .05$) positive relation between temperature and violent crime rate was observed, even after time series, age, and linear year effects were statistically controlled. On average, each 1°F increase in average temperature produced 3.68 more murders and assaults per 100,000 population. Nonviolent crimes were unaffected by average temperature.

Study 2 examined the effects of number of hot days ($\geq 90°F$) on the usual summer increase in violence. As expected, years with more hot days produced a bigger summer increase in violent crime than years with fewer hot days. Nonviolent crime was unaffected by the number of hot days.

SUMMARY OF TIME PERIOD EFFECTS

All told, time period studies produce an impressive array of support for the simple hypothesis that hot temperatures directly increase aggressive tendencies. Although routine activity theory can account for some of the results, it cannot account for all of them, as its supporters sometimes acknowledge (Field, 1992). The southern culture of violence position is totally silent on time period effects and thus cannot account for them.

CONCOMITANT STUDIES

As noted earlier, concomitant studies of the temperature–aggression hypothesis are actually a specific subcategory of time period studies. In concomitant studies, temperature and aggression are assessed at the same time. This allows stronger conclusions to be drawn in most cases because alternative explanations that rely on

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[4]The reader should note that our criticisms of methodology should not be taken as criticisms of the researchers. We know how very difficult it is to get archival data that meet the methodological requirements of complex research questions. The first author, for instance, has tried unsuccessfully to get acceptable data on prison aggression rates. We understand, and hope that our readers will too, that researchers in this area must make do with whatever data are available.

timing differences are automatically ruled out. An additional methodological advantage is that concomitant studies can be conducted in the experimental laboratory. As noted by Anderson (1989), however, laboratory studies of the heat effect have, on the whole, produced a very mixed set of results. This section first reviews the few concomitant studies of the temperature–aggression hypothesis in naturalistic settings, then reviews the laboratory studies via meta-analytic techniques, and finally presents evidence from our laboratory that resolves many of the questions raised by prior research.

NATURALISTIC SETTINGS

Two early studies of the temperature–aggression hypothesis in naturalistic settings used horn honking as a dependent measure of aggression. Baron (1976) delayed motorists by a confederate whose car sat through a green light. Aggression was measured by latency to horn honking. The study was conducted when the temperatures were in the mid-80°F range. Subjects were classified as having air-conditioned or unair-conditioned cars. Those without air-conditioning presumably would be uncomfortably warm, and therefore should be more irritated by the confederate's blocking of the intersection and should, on average, honk sooner. Among other things, Baron (1976) found that subjects without air-conditioning honked their horns sooner than those with air-conditioning. Although this appears to support the temperature–aggression hypothesis, we advise caution in interpreting the study this way because latency to horn honking may be especially instrumental for those without air-conditioning. Thus, it is not clear that the latency measure assessed affective aggression or a more instrumental intent.

The second study of this type also investigated horn honking in response to a confederate blocking an intersection (Kenrick & MacFarlane, 1984). These researchers, though, assessed latency to honk, number of honks, and total time spent honking. The last two measures are not differentially instrumental as a function of temperature or as a function of air-conditioning and therefore may be seen as measures of affective aggression. In both cases, once one has honked the horn the instrumental role of further honking is negligible. Because all three measures were highly intercorrelated and yielded the same results, a composite of them was created and reported by Kenrick and MacFarlane (1984). This study was conducted in Phoenix with temperatures ranging from 84 to 108°F. As expected, there was a significant linear effect of temperature on horn honking ($p < .01$). Furthermore, this effect was significantly stronger for subjects without air-conditioned cars ($r = .757$) than for subjects in cars with air conditioning ($r = .12$, $Z = 2.54$, $p < .02$).

Vrij, van der Steen, and Kippellaar (1994) reported a field experiment on the heat hypothesis conducted in a police station. During a regular shooting exercise using the Fire Arms Training System, 38 Dutch police officers were randomly assigned to the hot (80°F) or comfortable (70°F) condition. The Fire Arms Training System uses video and laser discs and audio systems to provide officers with realistic scenarios to which they respond as police officers. The officers use laser

"guns" in these scenarios. The scenario used in this study involved the officer responding to a burglary call at a shed and being confronted by a man holding a crowbar. The officers were videotaped during this session. After completing the scenario, each participant went to a comfortable room and completed several questionnaires measuring negative affect (annoyed and irritated), impression of the suspect (aggressive or not), impression of how threatening the suspect had been, and the officer's "tendency to shoot" the suspect. Finally, two measures of aggressive behavior were obtained based on the video tapes (percentage with firearm in hand, percentage who "shot" the suspect).

On each dependent variable, police officers in the hot condition displayed more negative responses than those in the comfortable condition. Hot participants reported more negative affect, a more aggressive impression of the suspect, a more threatening impression of the suspect, and a greater tendency to shoot the suspect; all these effects except the last one were statistically reliable. In addition, hot officers were significantly more likely to draw their weapon (41% vs 15%). Hot participants also "shot" more suspects (62%) than did cool participants (45%), but this difference was not statistically reliable.

On the whole, this work strongly supports the heat hypothesis. In all three naturalistic studies, hot participants behaved more aggressively than comfortable participants.

LABORATORY EXPERIMENTS

In many laboratory experiments, both temperature and anger have been manipulated to see if the heat effect is positive under low anger conditions and negative under high anger conditions. Anderson (1989) provides a detailed narrative review of most of the laboratory experiments on the temperature–aggression hypothesis. That article summarized the studies as follows: "On the whole, these laboratory studies . . . yield more confusion than understanding. Sometimes hotter conditions led to increases in aggression; at other times the opposite occurred. . . . The anger by temperature interaction sometimes occurred and sometimes did not. When it did occur, it usually took the form of a positive heat effect (increased heat–increased aggression) in nonangry conditions and a negative heat effect in angry conditions. In at least one instance the form was opposite" (p. 91).

Two studies were not included in that review. Baron and Lawton (1972) varied both temperature (hot versus comfortable) and whether a confederate modeled aggressive behavior. There appeared to be a weak negative heat effect in the no model conditions and a slightly positive effect in the aggressive model conditions, but neither effect approached significance. More recently, van Goozen, Frijda, Kindt, and van de Poll (1994) found no heat effect for either high dispositional anger or low dispositional anger subjects.

There has, nonetheless, been some controversy concerning whether the laboratory studies find effects consistent with the NAE model. [See Bell's (1992) com-

ment on the Anderson (1989) review article and Anderson and DeNeve's (1992) response.] A meta-analysis was performed on the entire set of published laboratory studies in order to more objectively examine this question (Anderson & Anderson, 1996). In all, 28 comparisons of comfortable and hot conditions were found. Overall, there was no hint of consistency (d_+ = .060, 95% confidence interval = [−.114, .234]).

The NAE posits that at low levels of negative affect, further increases in negative affect will increase aggression, but at high levels of negative affect, further increases in negaive affect will produce decreases in aggression because people will be focused on trying to escape rather than to aggress. Obviously, this is relevant only when escape and aggression motives lead to incompatible behaviors. The most common way of testing this interaction prediction in the temperature domain is to factorially manipulate temperature and anger. Thus, the prediction is that in high anger conditions hot temperatures should decrease aggression, whereas in low (or no) anger conditions the opposite should occur. Other context variables have also been manipulated, variables which either increase or decrease negative affect or willingness to aggress. For example, attitudinal similarity of the subject and the eventual target of aggression would decrease the negative affect whereas attitudinal dissimilarity and insult increase the negative affect. Thus, it is possible to categorize the experimental context on the basis of whether the nontemperature factors (e.g., insult, similar attitudes, cooling drink) produce a net increase in the negative affect. In the absence of hard data on the relative effectiveness of these different factors, we adopted the simple rule of assigning a +1 to positive factors (such as having similar attitudes) and −1 to negative factors (such as receiving an insult or having dissimilar attitudes). Conditions in which the net value of these nontemperature contextual factors was either positive or zero were placed in a "neutral context" category. Conditions in which the net was negative were placed in an "extra-negative context" category.

The 13 neutral context effects did yield a positive relation between temperature (hot vs comfortable), but it was just barely significantly different from zero (d_+ = .264, 95% CI = [.001, .526]). That is, hot temperatures appeared to increase aggression in these neutral context conditions, but not with great reliability. In contrast, the 15 extra-negative context effects yielded a negative heat effect, but this negative effect did not approach significance (d_+ = −.101, 95% CI = [−.333, .132]).

These results confirm Anderson's (1989) conclusions about the inconsistency of laboratory results in this domain. However, they also tend to fall in the direction predicted by NAE. Before leaving this issue, one additional caveat is needed. One of the studies that supports the NAE model at a behavioral level actually contradicts it in other ways (Palamarek & Rule, 1979). Specifically, these researchers included measures of escape motives and attributions for their affective state. Results of these measures contradict the NAE proposed mediating processes in two ways. First, the desire-to-escape measure yielded no significant effects; thus motivation to escape was not supported as a valid mediating variable. Second, subjects'

ratings of the extent to which their mood was caused by the situation paralleled the aggression choices. Those in the hot angry and the cool nonangry conditions attributed their mood more to the situation than did the other subjects. Therefore, using the aggressive behavior data as supportive of the NAE model is problematic at best and misleading at worst. Furthermore, if these effects are removed from the meta-analysis, the positive heat effect in the neutral context and the negative heat effect in the extra-negative context both get even weaker (d_+ = .250, 95% CI = [−.028, .528], d_+ = −.089, 95% CI = [−.332, .154]).

Normally, we put high value on the external validity of laboratory studies (e.g., Anderson & Bushman, 1997). However, as noted in earlier works (e.g., Anderson, 1989; Rule & Nesdale, 1976) the laboratory studies of the temperature–aggression hypothesis may be especially vulnerable to artifactual processes or may not include all of the interpersonal dynamic processes that normally operate in temperature-induced aggression in naturalistic settings. In either case, the result could well be inconsistent findings. Still, we firmly believe that a better understanding of heat effects as well as of affective aggression in general requires the precision and control available only in the laboratory. For this reason, we have (along with several others in our laboratory) been conducting laboratory research on heat and cold effects on aggressive behavior and on other aggression-related affects and cognitions. All of this work has been done in the context of a broad model of affective aggression, outlined earlier in this chapter. We turn now to a summary of what we have learned so far.

Temperature and Affect

State Hostility

In several studies we have investigated heat effects on a variety of types of affect. The results are quite consistent across study and paradigm. The most important affect from our perspective is what we have labeled "state hostility" (which is sometimes labeled as "anger"). The state hostility scale (Anderson et al., 1995) presents 35 statements (e.g., I feel furious) rated on five-point scales anchored at "strongly disagree" (1), "disagree" (2), "neither agree nor disagree" (3), "agree" (4), and "strongly agree" (5). Twelve items represent a lack of hostility (e.g., I feel polite); these are reverse scored. Across a number of studies we have shown that uncomfortably hot and uncomfortably cold temperatures increase state hostility (Anderson et al., 1996; Anderson et al., 1995; Anderson, Dorr, Anderson, & DeNeve, 1997). In general, participants in our studies report the least hostility at about 75–78°F. Cold temperatures in the 57–60°F range yield higher state hostility ratings than comfortable temperatures, and about the same as 93–96°F.

General Negative Affect

Similar increases have been found in general negative affect in hot and cold conditions, compared to comfortable ones (Anderson et al., 1996). Specifically, self-ratings on the general descriptors "upset" and "distressed" were significantly higher in the hot and cold conditions in that study.

Hostile Attitudes

In one study (Anderson et al., 1996), participants completed the Caprara irritability scale (30 items; Caprara, Cinanni, D'Imperio, Passerini, Renzi, & Travablia, 1985) and the Velicer attitudes toward violence scale (46 items; Velicer, Huckel, & Hansen, 1989) in a comfortable (i.e., 75°F) room after doing some cognitive tasks under varying temperature conditions. All items were combined to form an overall hostile attitudes scale. The Caprara items focus on beliefs about how one has typically behaved in the past (e.g., when I am irritated, I need to vent my feelings immediately). The Velicer items focus on beliefs about various aggressive ways of behaving (e.g., university police should beat students if they are obscene). Despite the fact that all people were in a comfortable room at the time they completed these items, those who had earlier been in the uncomfortably hot or cold condition reported significantly more hostile beliefs.

Temperature and Arousal

The effects of hot and cold temperatures on physiological and subjective measures of arousal were examined (Anderson et al., 1995, 1996). It was found that hot temperatures increase heart rate but decrease perceived arousal relative to comfortable temperatures. Conversely, cold temperatures decrease heart rate but increase perceived arousal.

Temperature and Primed Cognitions

In one study, Anderson et al. (1996) used a modified Stroop procedure to investigate the possibility that uncomfortable temperatures might prime aggressive thoughts. In the modified Stroop procedure, words were flashed on a computer screen in one of five colors. On each trial the subject's task was to name the color, not the word. Some of the words were aggression related (e.g., shoot) whereas others were not (e.g., chant). If uncomfortable temperatures directly prime aggressive thoughts, then naming the color of aggressive words should be relatively harder for subjects in uncomfortable temperatures. This modified Stroop task was sensitive to a photo prime manipulation; subjects who had seen and rated gun photos took relatively longer to name the colors of aggressive words (relative to control words) than subjects who had seen and rated photos of nature scenes. However, there was no effect of temperature on the color-naming task.

Temperature and Aggressive Behavior

Two studies relating temperature to aggressive behavior in modified versions of the Taylor competitive reaction time (CRT) paradigm (Taylor, 1967) have been completed. In the standard version of this paradigm, subjects believe that they are competing with another subject on a reaction time task. On each trial the "loser" receives an electrical shock punishment. The shock intensity and duration are supposedly set by the opponent. Thus, before each trial the subject sets the intensity and duration of shock to be used against his or her opponent on that trial should the opponent lose. The actual wins and losses, as well as the trial by trial shock

settings of the "opponent," are actually controlled by the experimenter. Intensity and duration as set by the subject are measures of aggression.

Experiment 1

A simple modification was made in the first study. White noise delivered through headphones was used as the punishment rather than shock. Subjects competed in 25 trials with their opponent. On each trial, participants responded to a tone by pushing a computer mouse button as soon as possible. Temperatures ranged from uncomfortably cold (56°F) to uncomfortably hot (96°F). Participants set the punishment level for their opponent prior to each trial.

In the standard paradigm as well as our first modification of it, the subject can use any of several motives in setting punishment levels. For instance, if angered the subject can set high noise levels to hurt the opponent. Because of the trial-by-trial nature of this task, the subject may refrain from setting high levels in order to prevent the opponent from responding in kind or the subject may adopt a tit-for-tat strategy in order to bring down the punishment level set by the opponent. Although the standard paradigm is well established, this ambiguity of subject motive may make it somewhat less sensitive to subtle effects, such as the heat effect, than is desired. Nonetheless, we kept this feature of the standard paradigm for our first experiment.

The pattern of punishments set by the "opponent" was also manipulated. For half of the subjects, their opponents gave consistently low punishments (selected intensities of 1–3 on the 0–10 intensity level scale). The other half of the subjects were initially given low punishment levels by their opponents, but across the 25 trials the intensity levels were increased.

As expected, subjects who received consistently low punishments by their opponent gave significantly lower punishments to their opponents than did those who received a pattern of increasing punishment. This was particularly true on the later trials, as shown by the provocation × trial block interaction [$F(2, 378) = 49.5$, $p < .0001$] depicted in Figure 10.10.

As expected, provocation also increased state hostility ($Ms = 2.19$ & 1.91), $F(1, 212) = 15.21$, $p < .0001$. In addition, both hot and cold temperatures led to higher levels of state hostility than did comfortable temperatures, as shown by the significant effect of a quadratic temperature term in the model [$F(1, 184) = 7.30$, $p < .01$]. Similarly, escape motives, assessed via a 23 item self-report scale, were also curvilinearly related to uncomfortable temperatures, with hot and cold subjects reporting heightened motives for escape [$F(1, 181) = 5.22, p < .05$].

However, temperature had no significant impact on noise intensity settings. This was true on the first setting, which was made prior to receiving any punishment by the opponent, as well as on each block of eight trials that followed. There are, of course, a host of reasons for an independent variable to fail to influence a dependent variable. In the present case, we believed that the standard procedure of having the subject and opponent set punishments for each other on a trial-by-trial basis instigated attempts to control the opponent. These attempts may well have overridden any increase in aggressive tendencies induced by hot or cold tempera-
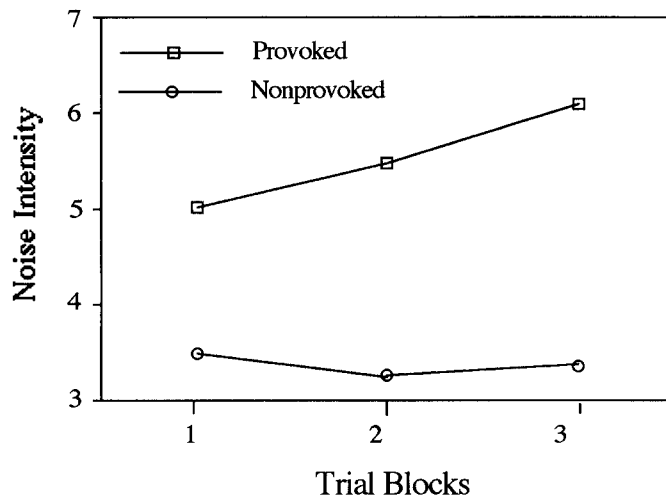
FIGURE 10.10   Noise intensity means by trial block and provocation.

tures. Alternatively, the low and high provocation manipulations themselves may have been so clear that they produced floor and ceiling effects, respectively, as soon as the subject figured out what the opponent was doing. To address these possibilities, we further modified the reaction time paradigm, and created what we call the retaliation reaction time (RRT) paradigm.

Experiment 2

In the RRT paradigm there are two sets of trials. One competitor sets punishment levels for the other on all trials in set one; the roles are reversed in set two. The real subject is always "randomly" assigned to receive punishment on the "lose" trials in set one, and therefore always sets punishment levels for the opponent in set two. This procedure allows subjects to retaliate for whatever transgressions they perceive were committed by their opponents during the set one trials, and to do so without fear of further retaliation by that opponent.

The temperature effect on aggression is likely a fairly subtle one. It may occur primarily as a brief outburst in reaction to some provocation. If this is true, then the RRT paradigm should be more sensitive to heat effects than the standard CRT, especially on the first trial in which the subject gets to set the opponent's punishment level.

This outburst by subjects in the hot and cold conditions should occur primarily when they have experienced some unwarranted aggression by the opponent, but not when the opponent's behavior during set one was either very nice (i.e., all low punishments) or very clearly not nice (i.e., systematically increasing punishment). To fully test this notion, a third pattern of opponent-set punishments was added. This set contained exactly the same frequency of each intensity setting as those in the original "high provocation" conditions, but instead of systematically increasing
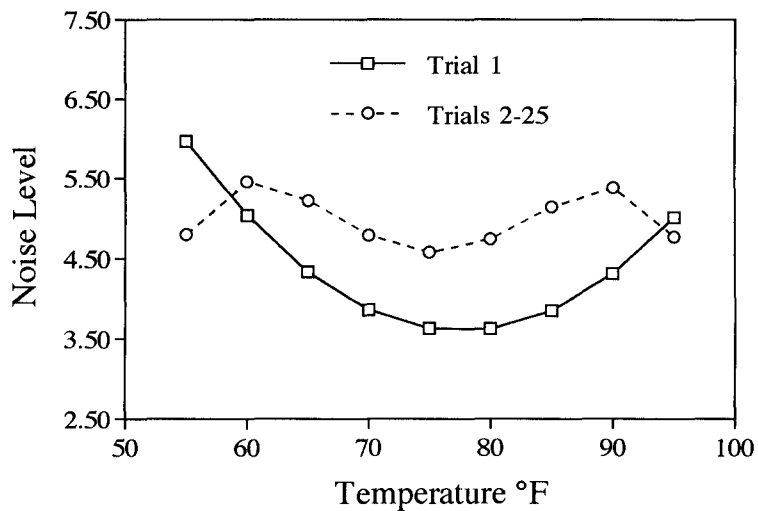
FIGURE 10.11   Noise level set by participants in ambiguous provocation conditions as a function of temperature and trial.

across trials, the various punishment settings were in a random pattern. In other words, there was no relation between trial number and intensity settings by the "opponent," thus creating ambiguity for the subject: "What is my opponent trying to do?" We expected these conditions—provocation with ambiguous intent—to be maximally sensitive to temperature effects. Here, the hostility state induced by uncomfortable temperatures can influence interpretation of the opponent's actions and of one's own state of anger. Once again, this should be especially true on the first trial for which the subject sets punishment for the opponent.

On subsequent trials the hot and cold subjects may well return to punishments that are very similar to those set by comfortable subjects. After all, the opponent has been justly punished. Indeed, for the last block of trials we expected that maximal aggression would occur by subjects in the moderately uncomfortable conditions. Hot and cold subjects may give relatively low punishments out of guilt over their earlier outburst or because that outburst fully satisfied their thirst for revenge or their desire to "set things right." Comfortable subjects may give relatively low punishments on these last trials because temperature never increased their hostility or their punishing behavior. Moderately hot and cold subjects, however, may well have increased feelings of hostility that are not expressed in an initial outburst and so they may continue to deliver moderately high punishments even in this last block.

Our results produced this very complex but meaningful pattern of aggression. On trial one punishments, there was a significant quadratic temperature × provocation interaction [$F(2, 191) = 3.74$, $p < .05$].[5] Further examination of the results

[5]Temperature was converted to deviation score form prior to analysis so that quadratic and linear effects could be examined simultaneously and meaningfully.

showed that, as expected, hot and cold subjects gave the most intense punishments to their opponent, but this curvilinear effect occurred only in the ambiguous provocation condition [$F(1, 63) = 5.45, p < .05$]. Figure 10.11 displays these results.

Interestingly, this outburst in the ambiguous provocation condition ended quite rapidly; by trial two it was no longer significant. Indeed, averaging over all subsequent trials yielded a downturn in aggression at the temperature extremes, although the downturn did not quite reach the low levels of aggression displayed by the most comfortable subjects. Interestingly, people in the moderately uncomfortable conditions gave the highest punishment levels on these subsequent trials, as shown by the significant quartic temperature effect [$F(1, 61) = 3.99, p = .05$], also displayed in Figure 10.11.

SUMMARY OF CONCOMITANT FINDINGS

Although much work remains to be done to cleanly establish the causal routes through which various temperature-related effects exert their influence on aggressive behavior, we now have a good start on drawing that road map. Consider first the laboratory conditions that produced the increase in aggression at hot (and cold) temperatures. It required a paradigm that could capture an outburst (RRT) and a provocation level that was maximally ambiguous. In the real world, of course, an aggressive outburst directed at a target will typically serve as a provocation for that target. As is well known to all (e.g., Bettencourt & Miller, 1995), provocation plays a huge role in instigating further aggression. Thus, the consistent increases in aggression at hot temperatures, found in geographic region and time period studies, could well result from this outburst phenomenon.

The quartic pattern found in subsequent trials of our RRT paradigm also provides some explanatory power for the violent crime data of various types. As many people have noted, hot days also have somewhat cooler periods. The elevated aggression displayed by our subjects in moderately warm conditions could well contribute to the overall pattern of increased aggression on hot days and in hot regions.

These data do not, however, completely detail the underlying psychological processes. For instance, even though we believe that escape motives will eventually prove to play an important role, there still is little evidence that directly supports the NAE.

KEY THEORETICAL MODELS REEXAMINED

We now examine each of the main theoretical models to see how they fit with data from each triangulation perspective. We focus on southern culture of violence, routine activity theory, and our general affective aggression model.

SOUTHERN CULTURE OF VIOLENCE

Although the SCV idea is a fascinating one, temperature data provide little support at best. The strong version of SCV claims (a) that heat effects are either

indirect or artifactual and (b) that regional differences in violence are due to the relative differences in endorsement of values associated with the SCV. There are several problems with this position. First, the SCV model implies that if regional differences in "southernness" are controlled in U.S. data, then heat effects must disappear. Our city violent crime data show, instead, that temperature remains a significant predictor even after controlling for southernness in various ways. Furthermore, when temperature is statistically controlled, the southernness effect disappears.

Second, the SCV model is totally silent on time period and concomitant studies of the temperature–aggression hypothesis because SCV is essentially controlled in both types of studies. The parsimonious explanation for regional differences in violent crime rates is temperature, not an additional cultural factor.

The third problem is the weak empirical base of general SCV theories as well as Nisbett's more specific culture of honor model. Note that we believe culture of honor effects exist as well as heat effects. Nisbett's studies provide hints of this (e.g., Cohen & Nisbett, 1994; Nisbett, 1993). What is needed to bolster the culture of honor model are studies showing the following: (a) Representative samples from high vs low culture of honor regions should differ in aggressive behavior, especially in public responses to public insults; (b) culture of honor scale scores should mediate the culture of honor/aggressive behavior relation in "a"; and (c) culture of honor scale scores should mediate aggressive behavior differences between "southern" and nonsouthern participants in laboratory studies. To date, none of the culture of honor laboratory studies has measured aggressive behavior. Cohen, Nisbett, Bowdle, and Schwarz (1995) measured the extent to which insulted and noninsulted southerners and northerners gave way to a large confederate in a hallway "chicken game" as well as the perceived firmness of the participants' handshakes. Insulted southerners tended to step aside later and to give firmer handshakes than northerners, but these measures relate to domineeringness. They do not meet standard definitions of aggression, and thus do not directly test the theory.

Similarly, there has not yet been a clear statement of what values and attitudes constitute the culture of honor, so there has not been an individual difference measure developed to assess culture of honor. Such a measure would be of immense value to the study of culture of honor and to violence more generally. It is hoped that future work will address these issues.

Finally, there are alternative explanations of the southern culture of violence that differ from the sociological theories and Nisbett's culture of honor model. One major historian (Wyatt-Brown, 1986) suggests that the violent aspects arose from the particular circumstances surrounding the institution of slavery and the need to maintain control. Other scholars (e.g., Pennebaker, Rimé, & Blankenship, 1996) have shown that climate plays a major role in the development of emotional expressiveness differences between cultures, a suggestion that fits well with our position that hot temperatures may contribute to the development of cultures of violence (Anderson & Anderson, 1996). In sum, although both temperature and cul-

tural explanations are likely to play a role in the violence in modern society, the southern culture of violence notion is not a viable alternative to the temperature–aggression hypothesis. It may best be thought of as a "partner."

ROUTINE ACTIVITY THEORY

The strong version of routine activity theory also states that heat effects are either indirect, working through the kinds of activities that people normally do in various temperatures, or artifactual. If RAT is the only factor underlying observed heat effects in time period studies, then the following predictions must hold: (a) Routine activities during hotter periods of time must differ in ways that increase aggressive behavior; (b) for different types of aggressive behavior, which differ in the kinds of routines that increase or decrease them, the observed time period heat effects should differ in corresponding ways (e.g., wife battering should not increase in the summer in the same way that assault does); (c) any regional heat effects should be related to regional differences in routine activities; and (d) there should be no heat effect in laboratory experiments or in field studies where routine activities are controlled. At this point in time, there is some limited support for prediction (a). Prediction (b) is contradicted by the time period studies in that all measured violent behaviors appear to show much the same time period heat effect. To our knowledge, prediction (c) has never been examined, i.e., no studies appear to link various high violent crime routine activities to geographic regions. Indeed, one of the major shortcomings of RAT is that too little is known about what routine activities promote what kinds of aggressive behaviors, about the temporal and spatial distribution of these routine activities, and about the intra- and interpersonal dynamics that link these routine activities to aggressive behaviors. It is an area ripe for more research. Finally, concerning prediction (d), concomitant studies and even some of the day-unit time period studies cannot be handled by RAT. For instance, the Reifman et al. (1991) study of batters hit by pitched baseballs cannot be explained by RAT.

A different version of RAT, one which accepts that heat directly affects aggressive tendencies, can reasonably posit that the relationship between heat and aggression might differ as a function of routine activities. Specifically, some "routines" reduce the opportunity for aggression. In such cases we would expect the link between heat and aggression to be attenuated. The Cohn and Rotton (1997) study provides some evidence for this version of RAT.

GENERAL AFFECTIVE AGGRESSION MODEL

This theory states that heat effects are both direct and indirect. It predicts that, all else being equal, hotter regions should have higher rates of aggressive behavior for those aggressive behaviors with a large affective/impulsive component. Region studies strongly support this prediction, even when all sorts of statistical controls are imposed. The theory also predicts that hotter regions will, on average,

develop more violent cultures. That is, people who grow up in hotter regions should have more positive attitudes and values toward aggressive behaviors, at least in certain kinds of circumstances. There is some support for this from the culture of honor literature (e.g., Cohen & Nisbett, 1994; Nisbett, 1993) and some from cross-cultural studies (e.g., Pennebaker et al., 1996; Robbins et al., 1972).

This theory also predicts direct heat effects in time period studies. Research consistently shows higher rates of aggression during hotter time periods in daily, monthly, quarterly, and yearly time period studies.

The general model makes a host of predictions concerning heat effects in concomitant studies, both in laboratory as well as in field settings. Research in the laboratory has resolved many of the inconsistencies found in earlier laboratory work and shows that hot temperatures do increase aggressive behavior in the laboratory. The few concomitant field studies of aggressive behavior also support the theory. In addition, the general model makes a host of predictions concerning possible routes through which hot temperatures (and cold) may influence aggressive behavior. We have shown that both affective and arousal routes may carry the heat effect from discomfort to (eventually) aggressive behavior. However, considerably more work must be done to test this model.

PROMISING DIRECTIONS

There are many promising directions for new research in this domain. We elaborate on some that are particularly exciting to us.

Development of a culture of honor scale would enable the testing of many hypotheses, both about cultures of honor as well as about individual differences in violence proneness. A culture of honor scale should be developed independently of indicators of aggressiveness so that the hypothesis that a culture of honor predicts aggressiveness can be fairly tested. Once developed, such a scale would also be useful in examining child development issues. How are these attitudes and values passed on? Are there alternative attitudes and values that could be substituted and that would be more beneficial to the individual and society?

More work is needed on the biological aspects. How can we relate biological factors (e.g., hormonal, neuronal) to heat effects on affective state, cognitions, attention, and arousal? Are some people more susceptible to such heat effects, perhaps because of their biological responsiveness to temperature?

As noted earlier, more work is needed on the specific ways that routine activities may be tied to heat effects on the one side and to violent crime on the other. Such work may be particularly important in its implications for crime control efforts.

Finally, the integrated model itself presents many research questions that, to date, do not have clear answers. Many of these questions involve temperature, of course. How does an uncomfortably hot temperature influence the interpretation

of ambiguously aggressive stimuli? Does it influence attributions people make for aversive events? How do individual differences interact with temperature and other aggression-related factors such as provocation?

APPLICATIONS

Throughout this chapter we have concentrated on the more purely scientific aspects of the temperature–aggression hypothesis. What are the underlying causes? Although the potential for application may seem obvious to many readers, we feel it important to at least briefly mention a few.

The integrated model itself suggests a host of ways that society can intervene to reduce unwarranted aggression. Some of these are not new ideas arising solely from temperature research, but instead can be derived from many contemporary research programs that are congruent with our own. For instance, by reducing children's exposure to aggressive material, especially to aggression that appears to be rewarded, we might be able to produce children (and later, adults) who are less prone to making hostile attributions for observed events (e.g., Dodge & Crick, 1990; Huesmann, Eron, Lefkowitz, & Walder, 1984). The role of temperature in the broad model also has implications. Many instances of violence in society begin as small disputes that escalate. If people were more generally aware of how hot temperatures can lead to attribution and interpretation biases, perhaps they could counteract them. Public service announcements about the need to "cool" one's temper as well as one's temperature during hot periods of time might produce a reduction in heat-induced aggression.

The various field study results themselves may be useful in some settings. For instance, knowing when and where violence is likely to erupt (e.g., hot days and nights, near bars) may be used to change police presence patterns in productive ways.

Finally, most people spend much of their lives in "built" environments. By making them more comfortable, we may be able to reduce unwarranted aggression. The most obvious places (to us, at least) are schools, prisons, homes, and the workplace.

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