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Temperature and Aggression: Ubiquitous Effects of Heat on Occurrence of Human Violence

Craig A. Anderson
University of Missouri—Columbia

Outlines 5 models of the temperature–aggression hypothesis: negative affect escape, simple negative affect, excitation transfer/misattribution, cognitive neoassociation, and physiological–thermoregulatory. Reviews relevant studies. Aggression measures include violent crime, spouse abuse, horn-honking, and delivery of electric shock. Analysis levels include geographic regional, seasonal, monthly, and daily variations in aggression, and concomitant temperature–aggression effects in field and laboratory settings. Field studies clearly show that heat increases aggression. Laboratory studies show inconsistencies, possibly because of several artifacts. Specific models have not been adequately tested, but the excitation transfer/misattribution and cognitive neoassociation approaches appear most promising, whereas the negative affect escape appears the least viable. Suggestions for future work are made.

The minds of men do in the weather share,
Dark or serene as the day's foul or fair.—Cicero

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.
—Shakespeare, *Romeo and Juliet*

For thousands of years, people have associated weather and human behaviors. For example, in Shakespeare's *King Lear,* the title character's madness is accompanied by violent storms. Often, more specific causal linkages have been proposed, as are demonstrated by the epigraphs.

The most common weather–behavior linkage is that between uncomfortably hot temperatures and violent or aggressive behavior. Our language is replete with imagery that reflects this linkage. Tempers "flare" when we fight; we get "hot under the collar" when frustrated; or we "do a slow burn" when angered. The basic temperature–aggression hypothesis is that the propensity for aggression increases at uncomfortably hot temperatures and that this propensity often overrides more rational considerations. As Shakespeare put it (in *The Merchant of Venice*), "the brain may devise laws for the blood, but a hot temper leaps o'er a cold decree."

Though the idea that hot temperatures may promote aggression has been around for ages, empirical tests of the idea awaited the development of a proper intellectual climate and corresponding technologies. In the late 1800s a number of social philosophers and social geographers began examining statistics on various types of crimes for evidence of temperature effects. (See Aschaffenburg, 1903/1913, Dexter, 1899, and Lombroso, 1899/1911, for presentations of this early work. See also Brearley, 1932, Cohen, 1941, and Falk, 1952, for reviews.) Presumably, this interest was sparked in large part by the availability of official criminal statistics as well as the speculations of Charles-Louis de Secondat de Montesquieu (in his *De l'esprit des lois,* 1748) and Henry Thomas Buckle (in his *History of Civilization in England,* 1857–1861).

Interest in climate effects on crime and aggression waned as developments in the various social sciences pointed the way to other determinants, such as traits and attitudes, social conditions, and biological factors. Indeed, recent thinking assumes either that climate effects are trivial or that they exert only indirect influence, by influencing the number of opportunities for aggression. More recent work, however, suggests that temperature effects are not trivial in magnitude and may not be simple by-products of aggression opportunity. Indeed, there is reason to believe that hot temperatures increase aggression through several (possibly related) psychological and biological processes. There is also reason to believe that considerably more focused research is needed. This review thus serves two functions: First, examination of the existing literature generates some answers to some very old questions about temperature and aggression; second, areas that need more work are identified.

Consider first what is meant by *aggression.* Many types of aggression have been identified in human and nonhuman research. A partial listing includes the following types: predatory, pain elicited, defensive, offensive, and instrumental. Different factors are involved in these different types, and probably differ somewhat between species. The temperature–aggression hypothesis applies primarily to those aggressive acts that are characterized by two motivational features. First, the motive to aggress is primarily affect based. Second, the motive is to harm the target in some way. Thus, predatory, pain-elicited, and instrumental aggression do not provide appropriate tests of the temperature–aggression hypothesis.

Organizational Scheme

The empirical studies of the temperature–aggression hypothesis have been grouped in this article according to the basic

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Correspondence concerning this article should be addressed to Craig A. Anderson, Department of Psychology, University of Missouri—Columbia, 210 McAlester Hall, Columbia, Missouri 65211.

methodology used. Thus, there are studies looking at differences in aggressive crime rates as a function of differences in (temperature related) geographic region. There also are studies of crime rate differences during various time periods, such as season, month, and day. Finally, there are studies in which temperature is measured concomitantly with the target behaviors.[1]

The overall logic of this review 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). Studies using different methodologies but addressing the same questions provide especially stringent tests of hypotheses. When the weaknesses of a particular type of study do not apply to the other types, consistency of results favoring a particular hypothesis allows one 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, one can be fairly sure that hot temperatures do have a direct effect on aggression.

Exactly how that effect works may require further examination of the types of studies. For instance, a biological theory of the temperature–aggression relation may posit that hotter ambient temperatures lead to increased testosterone, which in turn increases aggressive tendencies. This predicts increases in testosterone during hot summer months, corresponding to increases in aggression. If testosterone fails to show such cyclic effects, or if the upswing part of the testosterone cycle begins after the aggression cycle begins, its validity would be in doubt.

Basic Issues

Is There a Nonartifactual Temperature–Aggression Relation?

There are three basic issues. First, is there any evidence of a direct temperature effect on aggressive tendencies? A direct temperature effect is one that operates at the level of the individual, such as by increasing irritability or anger. Alternatively, are all findings of a temperature–aggression relation artifactual? Do increases in aggression occur in hot temperatures simply because both are associated with outdoor activities?

What is the Shape of the Temperature–Aggression Relation?

In the second issue, one assumes that there is a nonartifactual effect and asks about the shape of the relation. Five possibilities warrant attention. The simplest is a straight linear function, with aggression increasing as temperature increases. This function cannot be true at the extremes, because at extremely high and low temperatures the body cannot function properly, and death will ensue, precluding aggression. Thus, the shape question should be reframed and considered only within the normal range of temperatures. In this sense, the linear function is possible.

The J-shaped function also is conceptually simple. At low temperatures there may be little effect of temperature differences on aggression, whereas at higher temperatures the effect may be more pronounced. That is, the strength of the motive to aggress may be essentially the same at 20 °F and 30 °F, but 80 °F may produce much stronger aggressive motives than 70 °F.

The inverted-U shape specifies that aggression tendencies peak at some intermediate temperature (e.g., 85 °F) and decrease as temperatures deviate from this inflection point. A related shape is two inverted Us side by side (an M shape?). Aggression is low at very high and very low temperatures and at comfortable intermediate ones as well. Such a prediction does occur in a prominent model of affect and aggression, as will be seen shortly.

The fifth possibility is simply U shaped. This means that aggressive tendencies are lowest at some intermediate temperature (e.g., 65 °F) and increase as temperatures deviate from it.

Distinguishing among these functions is quite difficult, particularly in field studies. This is because of asymmetries in humans' abilities to handle nonoptimal hot and cold temperatures. It is easier to adjust to cold than to hot deviations from the ideal temperature (Persinger, 1980). Thus, even if the true functional relation between temperature and aggression was U shaped, studies that do not prevent subjects from adapting to the temperature (via clothing, for example) would tend to find either J-shaped or linear functions. Distinguishing between J-shaped and linear functions also is difficult in field studies, primarily because very precise assessments of aggression and concomitant temperatures are necessary. The most easily distinguishable shape is the inverted U, because only it predicts a drop in aggression at the highest (normal) levels of temperature. Even here, though, there is some ambiguity because of the uncertainty of where the inflection point should be located. An additional problem in assessing the shape arises in many of the laboratory studies. Typically, only two or three levels of the temperature variable are manipulated. A final problem in distinguishing among shape functions arises from the uncertainty of the temperature at the time the aggressive behavior was performed and at the time the aggressive motivation (intention, mood, or affect) was developed. Many murders committed during hot periods of time (e.g., months) may actually have been committed at the cooler times of that period and thus could be the result of an inverted-U–shaped function. On the other hand, even murders committed during the cooler parts of the time period may have been instigated by aggressive motives engendered during the hotter part of the time period.

Theories Relating Temperature and Aggression

Negative Affect Escape Model

There are five basic psychological approaches to the temperature–aggression relation.[2] The most widely cited and most con-

[1] My original intent was to report all studies purportedly addressing the temperature–aggression hypothesis. However, because of the number of such studies, space limitations, and the good sense of the reviewers and the Editor, some selection was necessary. Omitted were several widely cited and many obscure articles with severe methodological and interpretational problems.

[2] There must be effects at a sociological level as well, such as social interaction opportunity differences mentioned earlier as artifacts. Because there is little evidence relevant to such sociological effects of temperature on aggression, they will continue to be treated as artifacts to the psychological approaches under consideration in this article. Obviously,

troversial model is Baron and Bell's negative affect escape model (see Baron, 1979). In this model, competing behavioral tendencies of aggression and escape are instigated by negative affect. At low to moderate levels of negative affect the aggression tendency is stronger, so increases in negative affect produce increases in aggressive behavior. At high levels of negative affect the escape tendency becomes stronger. Therefore, if escape is possible, then further increases in negative affect produce both increases in escape behavior and decreases in aggression. This inverted-U–shaped model relates affect to aggression. If one is dealing with temperatures ranging from comfortably cool to uncomfortably hot, and if escape is perceived as an option, this model also predicts an inverted U for the temperature–aggression relation. The temperature at which a downturn in aggression is expected is not constant but presumably varies as a function of other factors producing negative affect. This inflection point should be relatively higher when there is no other source of negative affect. Baron and Bell's works (see review in the Concomitant Temperature section) suggest that the inflection point should be around 85 °F in most situations.

Another aspect of this model is important, though it has received little attention. Cold temperatures also produce negative affect. Therefore, another inverted-U shape is predicted as temperatures range from comfortably cool to unbearably cold. Thus, the negative affect escape model, by holding other sources of negative affect constant and with escape as a possible option, actually predicts an M-shaped function relating temperature to aggressive behavior.

This model is the most sophisticated one devoted to temperature effects on aggression. But it suffers conceptually for the same reason that it reveals something important. The prediction of decreases in aggression at extremely hot temperatures (and at extremely low ones as well) has to be true. Faced with the choice of risking heat stroke (or freezing) to aggress against an insulting target person versus escaping the situation but losing the aggression opportunity, most of us would choose escape. However, the desire or motive to aggress (the anger, hostility) may still be highest at the extremely hot (or cold) temperatures.

This example points out that the temperature–aggression hypothesis actually is more appropriately stated in terms of motive to aggress. Once stated in terms of desire or motivation to aggress rather than of actual aggressive behavior, the negative affect escape model becomes the same as the next model to be considered, the simple negative affect model. However, the addition of the assumption that escape motives increase with negative affect at a faster rate than aggressive motives leads to quite different behavioral predictions, which of course can be tested. That is, when escape is possible, the negative affect escape model predicts an inverted-U–shaped function between temperature and aggressive behavior as temperature ranges from moderate to uncomfortably hot or from moderate to uncomfortably cold.

It is important to note that because of difficulties in measuring motives to aggress, most scholars in this area have concentrated on aggressive behavior measures as indicators of motives. The implicit assumption has been that all else is equal (including other motives and behavioral possibilities, such as escape). Baron and Bell's work and this conceptual analysis make clear that all else is not necessarily equal in different situations.

Simple Negative Affect Model

This model is similar to the intuitive ideas passed down for generations. When people are hot, they are in bad moods. These moods make people more likely to respond to frustrations of various kinds by aggressing in some way. This model differs from the layperson's view primarily in that it applies symmetrically to cold temperatures as well. That is, negative affect results from being uncomfortably cold as well as uncomfortably hot. Thus, this model predicts a U-shaped function across the normal range of temperatures.

Excitation Transfer/Misattribution of Arousal Model

Zillmann's theory of excitation transfer (e.g., Zillmann, 1983a, 1983b) is easily applied to the temperature–aggression relation. The theory assumes that excitatory reactions, primarily in terms of activation of the sympathetic nervous system, are largely nonspecific across emotions. When large changes in excitatory reactions are experienced, people tend to link them to one salient inducing condition. Thus, arousal produced by excessive temperatures (for instance) may be misattributed to anger at some provoking individual.

This theory has received considerable support in a variety of contexts but has not been applied to temperature. Several conditions must hold for this theory to apply. First, excessive temperatures must lead to increases in arousal. Second, temperature-induced arousal must be misattributable; that is, hot temperatures must not be so salient a cause of arousal that they are seen by people as the inducing condition. If temperature is made salient as a cause of arousal, then portions of the total arousal that are actually due to nontemperature sources such as an insulting person may be misattributed to temperature, resulting in less anger at and artifactual decreases in aggression toward that person. If temperature remains nonsalient, though, hotter temperatures should produce misattributions of arousal to the annoying people in the context and increased aggression against these people. This is most likely to occur in conditions in which temperature is a background factor, which is true in most field studies.

The same logic holds for increasingly cold temperatures as well, assuming that the cold produces increased arousal and that the experience of arousal is not attributed to the cold. In many respects, then, this model of the temperature–aggression relation is a sophisticated version of the simple negative affect model. One key difference is that Zillmann's theory assumes that transfer effects on aggression can occur only if there is a salient target of aggression who instigates aggressive motives. The simple negative affect model assumes that the negative affect is itself sufficient to produce aggression without an interpersonal cause.

Cognitive Neoassociation Model

Berkowitz (1983a, 1983b, 1984) discussed several types of aggression in both animals and humans. The analysis most rele-

such effects would be important in their own right, and relevant research is badly needed.

vant to the temperature–aggression relation is the notion that uncomfortable conditions may prime aggressive thoughts that, in turn, increase the motive to aggress. The main idea is that aggressive thoughts and emotions are associatively linked to a variety of aversive conditions and experiences (cf. Geen & O'Neal, 1969). These conditions and experiences can prime the aggressive thoughts and related emotions, even when they are not particularly relevant or rational. These priming effects may, in turn, influence the person's interpretation of the situation and selection of behavioral alternatives. Thus, increasingly uncomfortable temperatures (hot or cold) should prime aggressive thoughts and produce more aggression, in a U-shaped function.

This prediction is essentially the same as that made by the excitation transfer theory and the simple negative affect model. A key differentiating prediction for Berkowitz's model is that uncomfortable temperatures should prime aggressive thoughts regardless of the presence or absence of aggressive cues in the situation. (Obviously, some situations may cue certain nonaggressive thoughts so strongly that aggressive ones are effectively shut out.)

Zillmann (1983a, 1983b) has not explicitly addressed the priming notion or temperature effects. But adding the assumption that arousal transfer can intensify dominant or salient cognitive processes leads to a prediction of increased aggressive thoughts at increasingly uncomfortable temperatures when the following conditions hold: (a) Aggression cues are present, and (b) temperature is a background factor. When aggression cues are absent, Zillmann's model would appear to predict no effect of temperature on frequency of aggressive thoughts. The simple negative affect model is silent on these matters.

The Berkowitz and Zillmann theories also differ in the importance of attributional processes. To excitation transfer theory, these processes are essential. The cognitive neoassociation model also states that controlled attributional processes, when operative, affect the motivation to aggress; it also claims that such misattributions are not necessary for discomfort to increase aggression. Because attributions may result either from conscious, accessible (and measurable) controlled processes or from spontaneous, inaccessible, and automatic processes (see Uleman, 1987), comparative tests of these two theories on the basis of attributional results will be problematic.

Physiological–Thermoregulatory Model

This approach is best seen as a different level of analysis. Unfortunately, the physiological literatures on temperature effects, temperature regulation, and aggression are far from clear. The ideas put forth here relating temperature to aggression via neural and hormonal systems must be viewed as tentative. Indeed, the linkages necessary for any reasonable thermoregulatory theory of temperature and aggression are so complex and poorly understood at the present time that testable predictions concerning shape or conditions of temperature–aggression effects are impossible. The purpose of this section is to demonstrate that there may be important physiological–thermoregulatory effects underlying temperature effects on aggression and that further thermoregulatory, neural, and neurohormonal research specifically addressing the temperature–aggression hypothesis is needed.

First, consider the basic effects of heat and cold on a variety of physiological systems. Exposure to hot temperatures generally produces the following effects: increased heart rate, increased respiration rate, deeper respiration, increased blood circulation rate, slight decrease in heart stroke volume, skin blood vessel dilation, sweating, decrease in thyroid-stimulating hormone and consequent decrease in basal metabolic rate, and increase in galvanic skin response (GSR) and skin conductance. Blood pressure effects have been inconsistent. Often, warm temperatures lead to a drop in blood pressure, though there is also evidence that systolic blood pressure increases in prolonged heat exposure. This list of effects generally is consistent with relative sympathetic nervous system dominance, but of course the decrease in blood pressure and the dilation of surface blood vessels are activated primarily by the parasympathetic system, contradicting such a general characterization. (For source material on these effects, see Bazett, 1927, Bloch, 1985, Hardy, 1961, Oken et al., 1962, Persinger, 1980, and Tromp, 1980.)

Exposure to cold produces a considerably shorter list of known effects: increase in heart stroke volume and consequent increase in circulation rate, shivering, vasoconstriction, increased blood pressure, increase in thyroid-stimulating hormone and cortisone (via pituitary control over the thyroid and adrenal cortex), and increase in epinephrine and norepinephrine (via the adrenal medulla). These last three hormones are all controlled to some extent by the hypothalamus, which is central in thermoregulation, and serve to increase basal metabolism. As with responses to heat, these effects reflect a complex interplay of the sympathetic and parasympathetic nervous systems. (For source material, see Bazett, 1927, Hardy, 1961, and Tromp, 1980.)

The most important locus of thermoregulation is the hypothalamus, though temperature-sensitive systems are found elsewhere, especially in the upper spinal cord (Bligh, 1973). Temperature-sensitive cells are connected directly (i.e., neurally) and indirectly (i.e., hormonally) to a variety of systems that control a variety of bodily and emotional functions. It is this incredible complexity that thwarts current attempts at a complete analysis.

The primary neurotransmitters involved are norepinephrine, epinephrine, serotonin, and acetecholine. When the first two are released in the hypothalamus (especially the preoptic region), a variety of events occur that lead to decreases in core body temperature. When the latter two are released in the hypothalamus, they trigger events leading to increases in body temperature.

All this is relevant to the temperature–aggression hypothesis in that many of the same neural and hormonal systems involved in temperature regulation are also implicated in aggression, but the links are not clear. For instance, testosterone levels have been linked to aggression in men and women (e.g., Blanchard & Blanchard, 1984; Olweus, Mattsson, Schalling, & Low, 1980). Sweating produces an increase in various corticosteroids from the adrenal cortex (Bligh, 1973). Corticosterone can suppress testosterone synthesis (Blanchard & Blanchard, 1984). At the same time, a relative lack of cortisol (another corticosteroid) has been linked to increases in aggression (Brain, 1984).

Similarly, the neurotransmitter serotonin seems to inhibit aggression (Persinger, 1980; Reis, 1974), whereas acetecholine increases aggression (Reis, 1974). But both are involved in thermoregulatory responses to cold (Bligh, 1973; Meyers, 1974).

What changes in aggression should be expected in cold because of these contradictory neurotransmitter effects?

Finally, it is intriguing to note the neural interconnectedness of a variety of structures linked to aggression, emotion, and thermoregulation, including the hypothalamus, amygdala, and hippocampus. It may very well be that emotional and cognitive effects of temperature result from such linkages. The systems are so complex, however, that there is little hope of understanding temperature–aggression effects at this level of analysis for quite some time. The area is promising, though, and more direct attacks on the temperature–aggression hypothesis from this perspective will undoubtedly yield new insights.

A Note on Arousal

A widely used construct in psychology is general arousal. It figures prominently in most treatments of emotion and motivation. The positions on the temperature–aggression relation outlined previously are no exception. A major problem with this construct is that at a physiological level, convergent validity is hard to find. That is, various indicators of arousal (such as heart rate, blood pressure, respiration, GSR) often yield modest to low (and sometimes negative) intercorrelations. Uncomfortably hot temperatures yield physiological effects that are both arousing and sedative; so do cold temperatures. Thus, a seemingly simple question such as "Do hot temperatures produce increases or decreases in arousal?" has no simple answer. Yet, such questions are crucial for many theories of the temperature–aggression relation. For example, the misattribution of arousal model applies only if there are perceived increases in arousal to be misattributed. Two solutions to this dilemma appear promising (and have been used in other contexts). First, one can define arousal not in physiological terms but subjectively; that is, one can ask subjects to assess if they are feeling aroused. Second, one can test the arousing properties of temperature by observing its effects on other behaviors. For example, Rotton (1985) convincingly demonstrated that people walk faster when it is hot, even when motives to escape from the heat were controlled.

Studies of Temperature–Aggression Hypothesis

Geographic Region Effects

The temperature–aggression hypothesis predicts that all else being equal, regions with more hot days will yield more aggressive behavior. This may occur with a variety of measures of aggression, such as aggressive crimes (e.g., homicide, assault, rape) or more common forms of aggression (e.g., fighting among children). Unfortunately, all else is seldom equal. A host of socioeconomic variables (including demographic and cultural factors) undoubtedly affect the expression of aggressive tendencies. These potential confounds limit the value of studies of geographic region effects. Such studies are particularly useful, though, if they have features that limit the confounds in some way. Thus, if the comparisons across regions with different temperatures are within the same country, the socioeconomic differences are likely to be reduced somewhat. The consistency with which geographical region effects are found across studies also is important. If the same temperature-related effects are found in several different countries, one's confidence that they are truly temperature related should be enhanced.

Of the three basic issues discussed earlier (i.e., existence, shape, specific theory), only that concerning the existence of a temperature effect on aggression can be cleanly tested. One possible finding would bear on the shape issue as well. Specifically, if maximum aggression rates are observed in regions with moderate climates, the linear, J-shaped, and U-shaped functions would be hard-pressed to explain them. However, a finding of maximal aggression in the hotter regions could be derived by the inverted-U-shaped function as well as by the other three shaped functions.

Studies With No Controls for Socioeconomic Factors

Numerous scholars have noted that aggressive crimes (i.e., interpersonal violence) are relatively more frequent in the hotter geographic regions of countries. Brearley (1932) presented data showing that the highest homicide rates in the United States from 1918 to 1929 were in the southern states. Other scholars have shown that the hot region/high crime effect is specific to violent crime. For instance, 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 (Guerry, cited in Brearley, 1932). Similarly, Lombroso (1899/1911) presented data showing that the homicide rate was relatively high in southern Italy (31 per 100,000 inhabitants), moderate in central Italy (15.24), and low in northern Italy (7.22), whereas aggravated theft was most common in central Italy (174.2) and equally less common in northern and southern Italy (143.4 and 143.3, respectively). Lombroso also reported that the homicide rate in the south of England was almost 10 times that of northern England. Finally, Lombroso cited some of his earlier work showing that homicide rates in Europe were higher in southern countries than in northern ones.

These early studies did not, of course, include statistical tests of the temperature–aggression hypothesis. However, some of the data were reported in a form allowing reanalyses and rough tests of the hypothesis. Lombroso (1899/1911), for instance, reported several aggressive crime rates by degrees latitude of the region, for both Spain and Italy. In Italy, rates of homicide and "resistance to officers" (presumably law officers) correlated significantly with latitude ($ps < .01$), with the higher rates occurring in the hotter latitudes. The Spain data yielded essentially identical results.[3]

Although Brearley (1932) did no comparable latitude analysis on his homicide data in the United States, it is apparent from those data that a comparable effect would emerge. Using Brearley's data, I computed the average homicide rate across the 1918–1929 time span for each of the northernmost and the southernmost states. (Note that expanding or shrinking the definitions of *northernmost* and *southernmost* states does not appreciably alter the results.) As was expected, the southern

[3] All p levels are based on two-tailed tests. For all reanalyses, descriptions of procedures and more specific results may be obtained by writing the author.

states had dramatically higher homicide rates ($M = 19.37$ per 100,000) than did the northern states ($M = 3.55$), $t(16) = 7.93$, $p < .001$. Sometimes such effects have been dismissed as due to the "culture of violence" in the U.S. south, resulting from historical social factors. However, the fact that the same pattern occurred in France, Italy, Spain, and England makes this alternative explanation considerably less tenable. Indeed, the data suggest that the hotter climates may have been causal factors in the development of cultures of violence (cf. the redux model proposed by Rotton, 1986).

Two more recent studies also have examined the geographic region effects without attempting to control for various socioeconomic factors. Robbins, DeWalt, and Pelto (1972) examined data bases containing aggression-related variables on various cultures around the world. They found that across cultures, warmer climates were associated with more indulgence of aggression, less induced anxiety in the socialization of aggression, more human agents of aggression in myths, and higher homicide rates (all $ps < .01$). Robbins et al. also reported several variables that did not show systematic variation as a function of temperature. The aggression-related ones were feelings of hostility in adults and incidence of warfare.

Schwartz (1968) briefly reported a study of political violence (e.g., revolts against the government) in 51 nations from 1948 to 1964. Nations were classified into quartiles based on the temperatures of "representative sites" in the countries. The frequency of political violence was then assessed as a function of the temperature quartile of the nations. The results showed that for this sample, violence was not more prevalent in the hotter nations. This study, like the Robbins et al. (1972) warfare results, contradicts the temperature–aggression hypothesis. The reason may be that the kinds of aggression studied (coups, political assassinations, terrorism, guerilla warfare, and revolts) are more planful, politically instigated acts. In other words, the temperature–aggression hypothesis applies to more spontaneous forms of aggression than revolution.

Studies With Controls for Socioeconomic Factors

Five studies have looked at geographic region temperature effects while simultaneously attempting to control for socioeconomic confounds. The first, by deFronzo (1984), examined the 142 largest standard metropolitan statistical areas (SMSAs) in the 1970 U.S. Census. Data on the seven major crimes reported by the Federal Bureau of Investigation Uniform Crime Reports (UCR), climatological data, and 11 various demographic and socioeconomic variables were compiled for each SMSA. The UCR includes murder, rape, assault, robbery, burglary, larceny, and motor vehicle theft. Of particular relevance here was the finding that a dummy variable reflecting the south/nonsouth status of each SMSA was highly correlated with both murder and assault rates ($ps < .01$). The rape/region correlation also was positive but nonsignificant. All three crimes were more prevalent in the southern SMSAs. These effects disappeared when all other variables in the data set were statistically controlled. Unfortunately, the interpretation of these regional effects is clouded by the fact that two of the variables that were statistically controlled were temperature-related variables (i.e., number of cold days in the year and number of hot days in the year in each SMSA). Thus, partialing out these temperature effects should reduce or eliminate region-based temperature effects. DeFronzo's data also yielded significant correlations between the temperature variables and the violent crimes of murder, assault, and rape. The number of hot days in an SMSA correlated positively and the number of cold days correlated negatively with these violent crimes (all $ps < .01$). Once again, when the effects of all other variables were first partialed out, these temperature–aggression effects tended to disappear, because the south/nonsouth variable is so strongly confounded with temperature.

Thus, at the level of zero-order correlations, deFronzo's data provide support for the temperature–aggression hypothesis. Southern cities and cities with warmer climates had relatively high rates of murder, assault, and rape. The laudable attempt to control for a variety of social differences between cities failed, though, because those regression analyses also partialed out temperature effects. (For other criticisms of deFronzo's analysis, see Rotton, 1986.)

Rosenfeld (1986) examined the seven UCR crime rates for 1970. In one analysis (of 125 urban areas), four variables were examined as predictors of crime: region (south/nonsouth), population, unemployment, and relative deprivation. Regression analyses revealed that southern cities had significantly higher rates of murder and assault but not of rape, robbery, burglary, larceny, or motor vehicle theft. In a second analysis (of 204 urban areas), five variables were examined as predictors of crime: region, population, unemployment, welfare eligibility, and welfare dependency. The regression analysis revealed that southern cities had significantly higher rates of all seven crimes except motor vehicle theft. The region effect was particularly strong, again, as a predictor of murder and assault.

Rotton (1986) examined the 1976 homicide rates of 41 countries and included several climate and sociodemographic variables. Specifically, he gathered 30-year average temperatures in January and July in the capital cities of the countries and a variety of other variables such as precipitation, life expectancy, literacy, and kilowatts per capita. The regression analyses yielded equivocal results, with some support for the temperature–aggression hypothesis. But a variety of methodological considerations (e.g., sample size, use of capital cities for assessing temperature distributions, use of 30-year average temperatures to predict 1-year homicide rates) make interpretation difficult. Thus, although the results provide some support for climatological models of homicide, this study is best viewed as too weak to be more than suggestive.

Rotton, Barry, and Kimble (1985) conducted a similar analysis of the three violent crimes of homicide, rape, and assault using 1977 crime data from 858 cities in the United States. The results varied somewhat depending on the particular analysis used, but in general, significant temperature effects were observed for all violent-crime variables. Once again, this study did not cleanly test the temperature–aggression hypothesis because the climate variables were inappropriate. Thirty-year averages were used, and only temperatures in January and July were sampled. Thus, the number of hot days in each city during 1977 was estimated only very poorly. The use of 30-year averages may yield some insight into effects of long-term climate on development of cultures of violence but may tell little of the direct effects of temperature within a given year.

The most extensive study of regional differences in aggression also examined crime rates in the United States (Anderson, 1987, Study 2). In that study, crime rates for each of 260 SMSAs (called *cities*) in 1980 were examined. Several climate variables were obtained for each city, including the number of hot days (90 °F or more) that occurred in 1980. Also collected were 14 social variables for each city such as unemployment, per capita income, education, age, and racial composition. In the first step of the analysis, social models of crime rate differences among U.S. cities were created for four violent and nonviolent crime indices. The purpose of these models was to partial out effects of potentially confounding variables. Thus, any variance shared among these predictors and temperature would be assigned to the social variables, not to temperature variables. These models were quite effective; they accounted for 56% to 79% of crime differences among cities. In the second step, climate variables were examined to see if any contributed unique variance in the prediction of crime, once the social model variables had been entered. As was expected, the various temperature-related variables all contributed significant unique variance to the prediction of violent crime ($ps < .01$). Temperature did not add anything to the prediction of nonviolent crime ($ps > .12$).

This study provides considerably stronger support for the temperature–aggression hypothesis than previous studies because it avoided many problems present in earlier work. More complete social models of crime were created and statistically controlled. Conservative tests of the unique contribution of temperature to crime were used. The effects of temperature on violent crimes were found to be significantly larger than corresponding effects on nonviolent crimes. Finally, region-based temperature effects were assessed at the more precise level of cities (actually SMSAs) rather than a simple south/nonsouth dichotomy.

Summary

The studies of geographic region temperature effects on aggression provide impressive support for the temperature–aggression hypothesis. The major problem with such studies is that at this level of analysis, there are numerous plausible alternative explanations of both supportive and contradictory results. For example, there may be historical development differences in cultures between regions that produce different aggression rates, and these differences may artifactually correlate with climatological differences. However, there is support in a wide variety of studies dating back to the early 19th century. Hotter regions in a variety of countries have shown relatively higher violent crime rates. Such high aggression is not paralleled by comparably high nonviolent crime rates. These temperature–aggression effects remain even when numerous potentially confounding factors are statistically controlled. Though such results can never be totally conclusive, the variety of supportive studies is suggestive of a strong, direct temperature–aggression relation. This type of work would benefit from replication attempts in very different settings. For instance, it would be quite informative to see analyses comparable to those presented by Anderson (1987) based on data from different parts of the world.

The shape of the temperature–aggression function was not resolved by these data. Indeed, all one can say is that these studies provided an opportunity for disconfirmation of the linear, J-shaped, and U-shaped functions and that disconfirmation did not occur. Similarly, the specific theories outlined earlier could not be tested.

Time Period Effects

The geographic region effects suffer from one additional interpretational problem, due to the level of analysis. Even though violent or aggressive behavior is shown by those studies to be relatively more frequent in regions with hotter climates, there is no evidence that the surplus violence occurred during hotter periods of time. The temperature–aggression hypothesis predicts, in decreasing order of time span, that hotter years, hotter quarters of the year, hotter months, and hotter days will be associated with relatively high levels of aggression, all else being equal. Of course, all else is seldom equal. For instance, homicides increase dramatically in frequency around Christmas in many regions, sometimes leading to an abnormally high body count for December and early January (e.g., Brearley, 1932; Rotton & Frey, 1985). The general strategy in examining time period effects is again one of triangulation: By looking at a wide variety of aggression phenomena in different contexts, controlling for as many potential confounds as possible, one may get a good overall look at the temperature–aggression hypothesis.

All the time period studies provide data relevant to the issue of the existence of temperature effects on aggression, of course. In addition, the studies in which the time period unit of analysis is days also allow an examination of the shape of the temperature–aggression function. However, the problems of distinguishing between the linear, J-shaped, and U-shaped functions discussed earlier all apply. Nonetheless, the inverted-U–shaped function at higher temperatures can be clearly distinguished and tested in some of the studies. Therefore, the Baron and Bell negative affect escape model is examined and discussed, where appropriate. These time period studies do not allow tests among the remaining four theories.

Effects of Hot Years and Seasons

Only one study was located in which differences in aggression were examined as a function of the hotness of years (Anderson, 1987, Study 1). To find temperature-related differences in aggression among years requires a very large data base, so that estimates of aggression will be reliable. Anderson (1987) studied the relative frequency of violent and nonviolent crimes in the United States (taken from the UCR) for a 10-year period (1971–1980) as a function of quarter of the year and of year. Temperature data from 240 weather stations were sampled for each year to estimate the differences in hotness among years. Thus, two types of predictions relevant to the temperature–aggression hypothesis were tested. First, it was expected that violent crimes would be particularly frequent in the third and (to a lesser extent) second quarters and relatively infrequent in the first and fourth. Second, it was expected that hotter years would display higher violent-crime rates. Both predictions were confirmed ($ps < .0001$). It was also predicted that temperature-related quarter and year effects on crime would be especially pronounced on violent crimes (in relation to nonviolent crimes). This specificity prediction was also strongly supported ($ps < .0001$).

Leffingwell (1892) examined quarter-of-year effects on two broad categories of violent crime in England and Wales for the years 1878–1887. One category included murder, attempted murder, and manslaughter. After adjusting the data for the slightly different number of days that occur in the different quarters, I performed a 10 × 4 (Year × Quarter) analysis of variance (ANOVA) and used the interaction as the error term. There was a significant quarter-of-year effect, $F(3, 27) = 6.03$, $p < .01$. As was expected from the temperature–aggression hypothesis, these "murderous assaults" were most frequent in the third quarter (July, August, September). Indeed, the third-quarter mean was significantly higher than any of the other quarters (all $ps < .05$).

The second category of violent crime reported by Leffingwell was "Crimes Against Chastity," which included sexual assaults and rape. The same 10 × 4 ANOVA was performed on these data, resulting in the same type of quarter effect, $F(3, 27) = 29.25$, $p < .0001$. Once again, these violent crimes were significantly more frequent in the third quarter than in any other (all $ps < .05$).

Though both types of crimes showed the same pattern and confirmed the temperature–aggression hypothesis, it is interesting to note that the sexual assault data were considerably more reliable statistically than the homicide-related data. Although there are several plausible interpretations for this, the simplest is that the former were much more frequent than the latter, and thus the quarter-to-quarter estimates may be relatively less influenced by random fluctuations.

More recently, Cerbus (1970) failed to find a significant seasonal effect on homicide frequencies in Ohio for the period of June 1962 to May 1967. The total number of homicides during this period may have been too small to provide a sensitive test of the hypothesis. Interestingly, the peak did occur in the summer months.

Lombroso (1899/1911) reported several data sets relevant to the time period temperature–aggression hypothesis, including several gathered by earlier researchers. Two types of violence measures amenable to statistical reanalysis were reported. One concerned rapes by month of year and is examined in a later section. The other concerned "uprisings," by which is probably meant political rebellions and riots, by season of the year. Lombroso's (1899/1911) report was based on an analysis of "the 836 uprisings that took place in the whole world in the period between 1791 and 1880" (p. 5). He found that on the whole such uprisings occurred more frequently in the summer months. Lombroso (1899/1911) reported that "in Europe the maximum proved to be in July, and in South America in January, which are respectively the two hottest months. The minimum falls in Europe in December and January, and in South America in May and June, which again correspond in temperature" (p. 6). The actual frequency of uprisings is reported only for European countries (16) by season (spring, summer, autumn, and winter). In 10 of these countries there were fewer than 25 uprisings, and they were thus deleted from my reanalysis. The remaining six countries were divided into the three having the highest frequency of uprisings (61 to 99) and the three having the lowest frequency of uprisings (25 to 29), and the data were analyzed with a 4 × 2 (Seasons × High vs. low frequency) ANOVA. As was expected from Lombroso's description of the results, a strong season effect emerged, with summer being the most popular time period for uprisings, $F(3, 16) = 7.55$, $p < .01$. Indeed, the summer average was significantly higher than any other period (all $ps < .05$).

One obvious question at this point is why Lombroso's (1899/1911) uprising data are so strongly related to season, given that Schwartz (1968) found little evidence relating temperature to political violence. One possibility concerns methods. It may be that in Schwartz's geographic regional analysis the political climate of his sample of nations was correlated with temperature and region in such a way as to hide any true temperature effects. Lombroso's seasonal analysis within countries eliminates many such confounds. Within Spain, for example, which experienced 99 incidents, the political climate probably was pretty much the same in the spring, summer, autumn, and winter.

A second possibility is that the definition of countable incidents varied between the two studies. Schwartz's (1968) definition seemed to be based on planful acts of rebellion or revolution rather than on more spontaneous forms of aggression. In any case, Lombroso's (1899/1911) uprising data lend further support to the temperature–aggression hypothesis, though the lack of specific methodological detail warrants some reservations.

Rotton and Frey (1985) examined the relations among air pollution, temperature, humidity, and two types of aggressive behavior (assaults and family disturbances) in Dayton, Ohio, for a 2-year period (1975–1976). A variety of complex regression analyses were reported, most of which are beyond the scope of this article. The basic findings of relevance here were that both types of aggressive behavior were significantly influenced by season ($ps < .0001$). Specifically, assaults and family disturbances were most frequent in summer and least frequent in winter.

Chang (1972) reported the frequency of three categories of assault (assault, injury, other assault) and rape by season in Korea in 1964. After correcting for slightly differing numbers of days in the seasons, I computed a chi-square for each type of aggressive crime. In each case the summer months were associated with the highest frequency of aggressive crimes ($ps < .001$).

Figure 1 displays the results of these studies via a plot of the percentage of the total violent incidents by time period. Note that the Anderson (1987) and the Leffingwell (1892) results are by quarter; the others are by season.

Effects of Hot Months

The majority of time period studies used months as the unit of analysis. In this section all such studies having sufficient information for statistical analysis by month are presented. For ease of exposition the studies are grouped by type of aggression measure.

Homicide. Five studies each included large numbers of homicides and were gathered over periods of time ranging from 2 to 6 years. Each of these five is reviewed briefly. Then, I present an aggregate analysis to get a good overall look at monthly effects on homicide. Such an analysis across studies and years is useful both as a meta-analytic tool and because it reduces any unwanted distortions in observed effects due to extraneous factors such as unusual temperature patterns and unusual distribution of high-violence days (e.g., weekends) by month in a particular year.

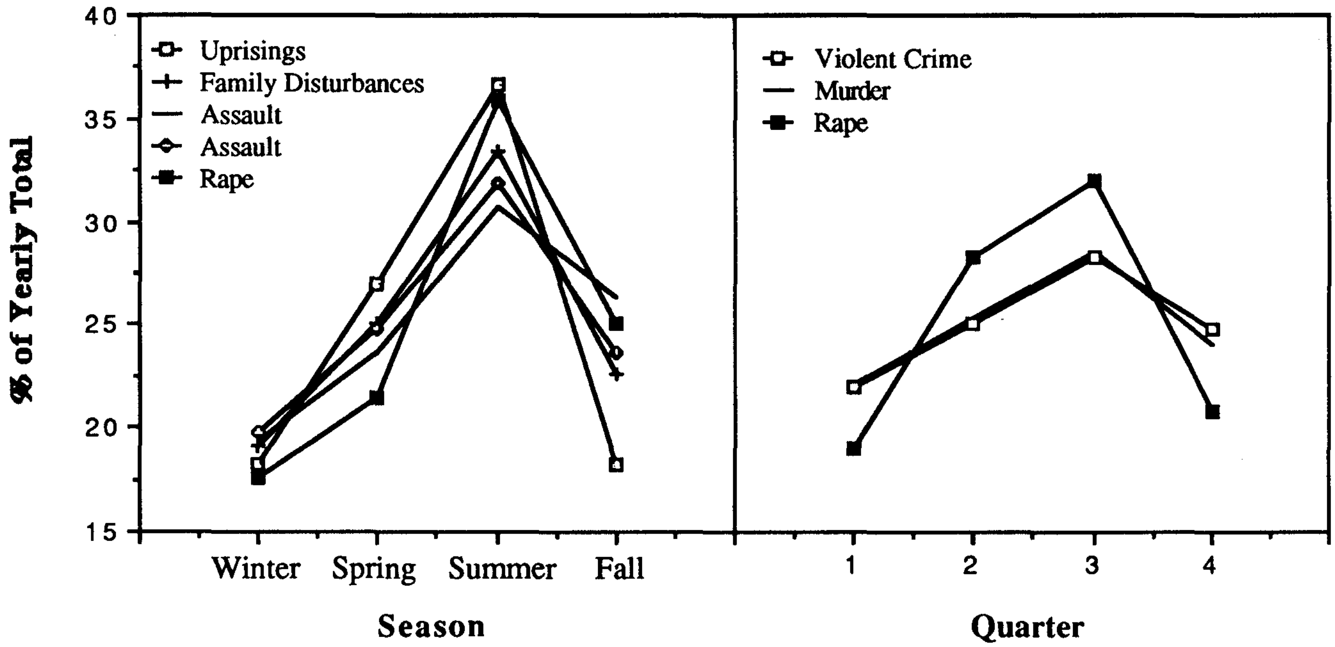

Figure 1. Quarterly and seasonal distribution of aggressive behavior. (Quarterly data are from Anderson, 1987 [violent crime], and Leffingwell, 1892 [murder and rape]. Seasonal data are from Lombroso, 1899/1911 [uprisings], Rotton and Frey, 1985 [family disturbances and assault (solid line)], and Chang, 1972 [rape and assault (diamonds)].)

Brearley (1932) examined homicide rates for the entire United States by month (corrected to 31 days per month) for the years 1923–1928. Although Brearley claimed that these data contradict the temperature–aggression hypothesis, a reanalysis yields somewhat different conclusions. I performed a 12 × 6 (Month × Year) ANOVA on these data, using the interaction term for an error term. The analysis yielded both a significant month effect, $F(11, 55) = 7.28$, $p < .01$, and a significant year effect, $F(5, 55) = 39.17$, $p < .0001$. The pattern of monthly means yielded one major and one minor anomaly from the view of the temperature–aggression hypothesis. December was considerably too high, and November was slightly too high. I will return to these in a moment.

The strong year effect was that the number of homicides increased linearly and dramatically with time. There are at least three plausible sources of this effect. First, these data were not corrected for increases in population size. Second, the actual rate of homicide may also have been increasing during this time period. Third, the reporting rate of homicide may have been increasing (on the basis of definition or detection changes). Correcting for this time trend artifact resulted in monthly averages more in line with the results of other studies and the temperature–aggression hypothesis. Specifically, homicide was most frequent during the hot summer months of July and August. December still was abnormally high, but the Christmas effect most likely accounts for this.

Cohen (1941) reported a study of homicide and assault in the United States from 1935 to 1940. (The assault data are reported in the next section.) Within each year, the monthly rate was expressed as a percentage of the annual rate, then converted to a base of 100. The monthly averages of these scores were then reported by Cohen. A reanalysis of these data resulted in a highly significant month effect ($p < .001$). The hotter months and December had the most homicides.

Iskrant and Joliet (1968) reported the percentage of U.S. homicides occurring in each month during the years 1959 through 1961, out of a total of over 25,000. Lester (1979) reported the average number of homicides per month in the United States during 1972 (50% sample) and 1973, with a total of over 30,000. In both sets, homicide was most frequent in the hot summer months. Furthermore, as in earlier homicide studies, there was also an increase in December. These month effects were highly significant for each study ($ps < .001$).

Michael and Zumpe (1983) examined monthly changes in murder, rape, assault, and robbery in 12 states, Puerto Rico, and 3 cities (Honolulu, Los Angeles, and San Francisco). For each of these 16 locations, monthly totals of these crimes were obtained for at least 2 years, but for no more than 4 years, from 1975 to 1979. Despite the relative infrequency of some of these crimes (especially murder) and the short duration of the study, analyses were conducted separately for each location. (The rape and assault results are presented in later sections.) The data analysis of primary relevance here was a cosinor method for determining the presence of statistically significant annual rhythms. Briefly, a best fitting cosine function is fit to the monthly data, the significance is estimated, and the timing of the annual rhythm maximum is estimated.

Murder did not show consistent cosine patterns. Although these murder data cannot be seen as supporting the temperature–aggression hypothesis, the failure here is most likely due to the relative infrequency of murder and the corresponding high instability of murder rates within limited time frames. To ex-

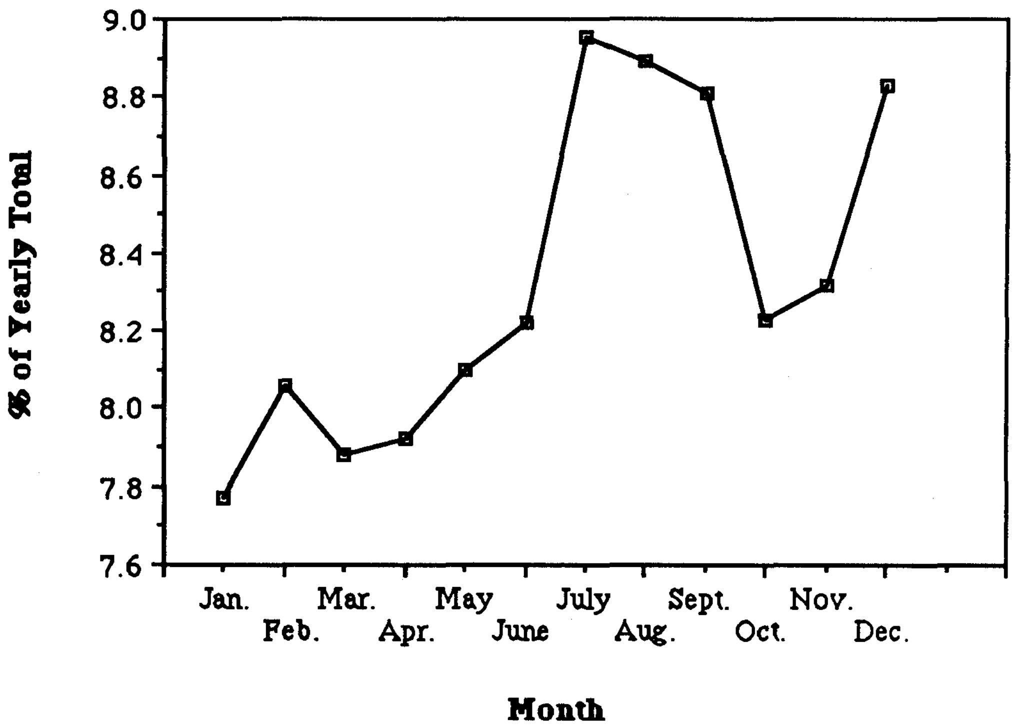

Figure 2. Monthly distribution of homicides. (These averages are based on data from Brearley, 1932, Cohen, 1941, Iskrant and Joliet, 1968, Lester, 1979, and Michael and Zumpe, 1983.)

amine this possibility, I totaled the homicide figures by month across all 16 locations.[4] Even though the total number of murders was still considerably smaller than that in the previous four studies, the pattern was essentially the same. There was a significant effect of month ($p < .01$), with the highest monthly totals in the summer and in December.

To get a better overall look at the monthly variation in homicide, I calculated the percentage of yearly murders that occurred in each month, for each of the five studies, adjusting for the number of days in each month. An ANOVA on these percentages yielded a highly significant effect of months, $F(11, 44) = 13.06$, $p < .001$. As can be seen in Figure 2, July and August were the high murder months, closely followed by December.

Assault. Seven major data sets on the monthly distribution of assaults were located. Each is reviewed briefly. Then I present an aggregate analysis to get a better look at the overall month effect.

Dexter (1899) examined the effects of temperature-related variables on two aggression measures, assaults in New York City from 1891 to 1897 and murders in Denver from 1884 to 1896. (The Denver murder data were not presented in a fashion allowing meaningful statistical analysis and were not considered in the previous section.) Although Dexter's assault data were not in a form easily amenable to statistical analysis, enough information was presented to allow a reanalysis by months of the year. For each month I was able to estimate the average number of assaults per day in that month, averaged across years. Dexter also reported the average daily temperature for each month. Thus, one can see if the hotter months tended to have the highest assault rates. As was expected, the monthly assault rates were highly correlated with temperatures ($r = .986$, $p < .01$). The summer assault rates were about 20 per day, whereas the winter rates were about 12.5 per day.

Recall that Cohen (1941) also reported monthly assault rates in the United States from 1935 to 1940, using a base of 100. As was expected, the peak in assaults occurred in July, August, and September, whereas the valley occurred in January ($p < .001$). Michael and Zumpe's (1983) analysis of assaults in 16 different locations further supported the temperature–aggression hypothesis. Their cosinor analyses of assaults revealed significant annual rhythms for 12 of the 16 locations ($ps < .05$). For all 16 locations the rhythm maximum occurred in July, August, or September.

Perry and Simpson's (1987) study of violent crime in Raleigh, NC, yielded a significant month effect on aggravated assault ($p < .01$). The largest number occurred in July.

Aschaffenburg (1903/1913) presented a data set consisting of the monthly distribution of 15 categories of crime in Germany during the period 1883–1892. The monthly distribution of each crime type was standardized by Aschaffenburg to a rate of 100 per day. Thus, for any crime, a monthly figure of 100 meant that exactly the average annual rate per day of crime was obtained in that month. Higher figures indicated proportionally higher rates per day; lower figures indicated proportionally lower rates per day. Two of the categories were assaults, simple and aggra-

[4] I am extremely grateful to Richard P. Michael and Doris Zumpe for providing me with the data necessary for these computations. Note that they also provided their data necessary for the aggregate analyses and the figures on monthly distributions of homicide, assault, rape, and wife beating. In all cases these data were adjusted to correct for the different number of days in different months.

vated. In my reanalysis, each type of assault was treated as a separate replication in a one-way ANOVA. As was expected, the relative frequency of both types of assaults peaked in the hotter months, whereas the colder months displayed the fewest assaults, $F(11, 11) = 153, p < .001$.

Dodge and Lentzner (1980) reported the assaults per month in the United States for the 1973–1977 period. An ANOVA yielded highly significant month effects, $F(11, 44) = 6.75, p < .0001$, with the most assaults occurring in the warmer months.

These seven data sets were aggregated in an ANOVA to get a better view of the monthly distribution of assault. (Aschaffenburg's [1903/1913] simple and aggravated assault sets both were used.) As was expected, there was a highly significant effect of month, $F(11, 66) = 18.70, p < .001$. Figure 3 displays the mean monthly distribution of assault in percentages, averaged across the seven data sets and adjusted for number of days per month. The results are strikingly supportive of the temperature–aggression hypothesis.

There was no hint of a December increase in assault corresponding to the December increase in homicide. One plausible explanation for this difference concerns the nature of the homicide increase. Several researchers have suggested that the increased homicides in December result primarily from family quarrels. Although this might seem to suggest that assaults also should increase, it is probably the case that within families, assaults are relatively unlikely to be reported to the police. Obviously, within-family homicides cannot be correspondingly underreported.

One other assault study warrants mention here. Harries and Stadler (1983) gathered assault data from Dallas police reports for the 8-month period of March–October 1980. During that summer, Dallas experienced an amazingly severe heat wave. Harries and Stadler examined the effects of a number of variables, including month. As was expected, month exerted a significant effect on the daily frequency of assaults ($p < .01$). The hottest months, July and August, had the highest assault rates. Harries, Stadler, and Zdorkowski (1984) reported additional analyses on the same data set. They further categorized assaults on the basis of where they occurred, specifically, in high, medium, or low socioeconomic status (SES) neighborhoods. They hypothesized that the hot-summer effect on assault rates might be more pronounced in lower socioeconomic areas because the people there are less able to ward off extreme heat stress with such conveniences as air conditioners. A graphical display of the Month × SES interaction supported this prediction, but no statistical test was reported.

Rape. A large number of scholars have examined the monthly distribution of rape. Several of the resulting data sets were fairly small in scale, whereas others were somewhat larger. Four studies have reported monthly rape frequency distributions with relatively few incidents (i.e., averages of about 24 to 60 per month). Hayman, Lanza, Fuentes, and Algor (1972) studied rapes occurring in Washington, DC, from July 1969 through December 1970. Amir (1971) studied rapes in Philadelphia for the years 1958 and 1960. Lombroso (1899/1911) reported monthly average incidence of rape data from Italy in the year 1869. Perry and Simpson (1987) reported rape frequencies by month for Raleigh, NC, for 1972–1981. Reanalyses showed that in all four studies the monthly distribution of rape increased in the hotter months ($ps < .05$).

One additional report was based on a fairly small number of rapes. Smolensky, Reinberg, Bicakova-Rocher, and Sanford (1981) used the cosinor method to analyze monthly variations in rape frequency in Houston for 2 years (1974–1975) and in Paris for 6 years (1973–1978). Significant monthly effects were found in each ($ps < .005$), with peaks in the summer months.

Larger scale studies of the monthly distribution of rape also support the temperature–aggression hypothesis. Michael and Zumpe's (1983) study of crime in 16 locations, discussed earlier, included rape. Their cosinor analyses yielded significant annual rhythms in 14 of the locations ($ps < .05$). The rhythm maximums occurred in July, August, or September, except for Puerto Rico, where the maximum occurred at the end of May.

Aschaffenburg (1903/1913) reported the frequency of sexual crimes in France from 1827 to 1869 by month. (These data were originally gathered by Ferri, cited in Aschaffenburg, 1903/1913.) Separate tallies were reported for adult and child victims. For each type I computed the average sexual crimes per day by month, to adjust for differing number of days per month. Then I analyzed these averages in a 12 × 2 (Month × Adult vs. child victims) ANOVA, using the interaction term as the error estimate. As was expected, there was a significant month effect with a peak in the warmer months of June and July, $F(11, 11) = 2.98, p < .05$.

Lombroso (1899/1911) reported monthly average incidence of rape data from England for the years 1834–1856 and from France for the years 1829–1860. Both data sets were reported only in percentage terms, making a reanalysis impossible. The France data overlapped with similar ones reported by Aschaffenburg (1903/1913), so Lombroso's France data are not discussed further here. Finally, recall that Aschaffenburg's (1903/1913) report on the monthly distribution of 15 crimes in Germany (1883–1892) included rape. These figures were standardized to a rate of 100 per day, and no total number of rapes was reported. Therefore further individual analysis was not possible. In both cases (England and Germany data), however, the monthly distribution strongly supported the temperature–aggression hypothesis. Rape increased dramatically in the hotter months and fell in the colder months.

To get an overall view of the monthly distribution of rape, I conducted an aggregate analysis. For each data set the monthly percentage of the yearly total (adjusted by number of days per month) was computed. Four of the data sets were based on small numbers of incidents (Amir, 1971; Hayman et al., 1972; Lombroso's [1899/1911] Italy; Perry & Simpson, 1987). Four of the data sets were based on relatively large numbers of incidents. For Michael and Zumpe's (1983) data on 16 locations, I summed incidents across locations. (I was unable to obtain the necessary data to do the same with the Smolensky et al. [1981] data.) The remaining large data sets were from Lombroso (1899/1911; England) and Aschaffenburg (1903/1913; Germany and France). The 2 × 12 (Size of data set × Month) ANOVA on these data revealed a strong month effect, $F(11, 66) = 16.71, p < .001$. There were no main or interaction effects of data set size ($Fs < 1$). Figure 4 presents the adjusted monthly percentage of rapes, averaged across these studies. It is obvious that the data overwhelmingly conform to what is expected from the temperature–aggression hypothesis. Rapes peak in frequency in June, July, and August.

One alternative explanation of the rape data warrants men-

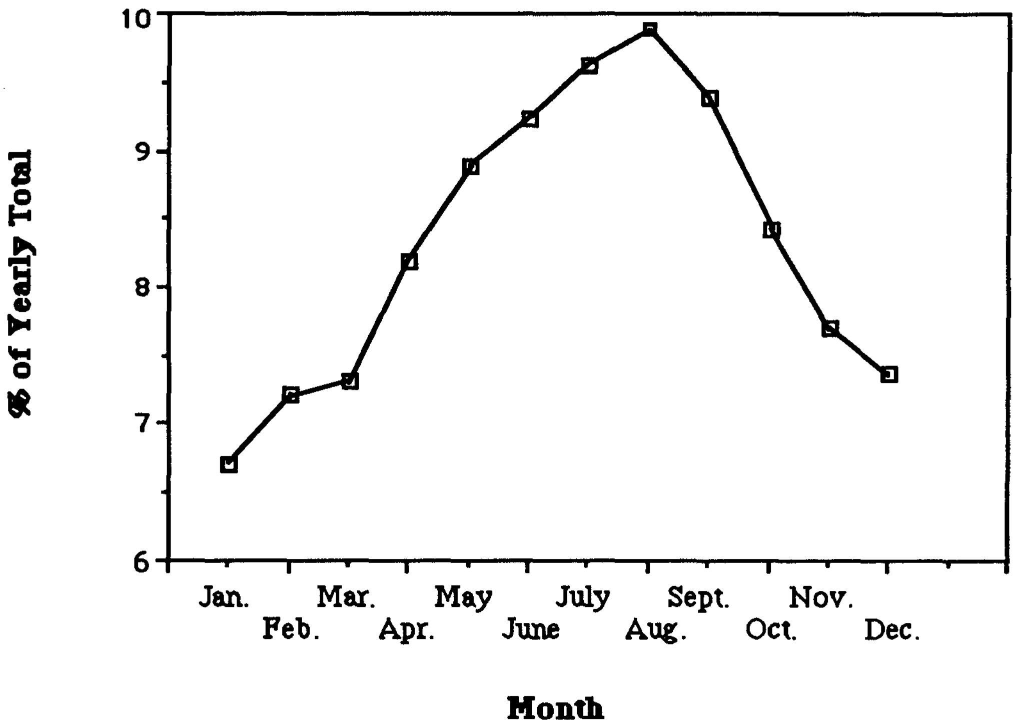

Figure 3. Monthly distribution of assaults. (These averages are based on data from Aschaffenburg, 1903/1913, Cohen, 1941, Dexter, 1899, Dodge and Lentzner, 1980, Michael and Zumpe, 1983, and Perry and Simpson, 1987.)

tion here. Smolensky et al. (1981) interpreted their results as being due to circannual changes in plasma testosterone levels. Two observations make this alternative plausible. First, other research suggests that testosterone levels in men vary on an annual cycle, with peaks in late summer to early autumn (Reinberg & Lagoguey, 1978; Smals, Kloppenborg, & Benraad, 1976). Second, high testosterone levels have been linked to aggression and sexual aggression in other work (see Blanchard & Blanchard, 1984; Brain, 1984; Olweus et al., 1980). The problem with this interpretation is that across a variety of monthly rape data sets, it appears that the rise in rape frequency begins much earlier in the year, and the peak occurs much earlier, than the increases in testosterone levels supposedly causing it. Of course, more data on this issue are needed.

Miscellaneous aggression measures. Aschaffenburg's (1903/1913) report on the monthly distribution of 15 categories of crime in Germany during the period 1883–1892 included several other aggressive crimes. Four crimes were eliminated from further consideration because of various ambiguities. Three (crimes and offenses against national laws, obscene acts or distribution of obscene literature, and malicious mischief) were deleted because it is not clear what these crimes are and whether they are aggressive. A fourth (infanticide) was deleted because its monthly distribution is known to have been heavily influenced by a nontemperature factor, namely, monthly birthrate. The three remaining aggressive crimes were resisting officer, breach of peace, and insult (Beleidigung). An ANOVA on these crimes yielded a significant month effect, $F(11, 22) = 8.71, p < .0001$. As can be seen in Figure 5, the miscellaneous aggressive crimes were most frequent in July, August, and September, and least frequent in December and January. Interestingly, the nonaggressive crimes reported by Aschaffenburg increased in December and November; April and September had the fewest.

A note on the social contact alternative. An interpretational problem with the time period results concerns the underlying causal mechanism. Do these time period results occur because of some direct influence of uncomfortably hot days (e.g., irritability) on aggressive tendencies? The most obvious alternative explanation is that time period results are spurious artifacts or indirect effects of differential socializing patterns. Perhaps violent crimes increase during hot periods because people get out more, are on vacations (from school or work), or congregate in large groups more during the summer than during other seasons. The wide variety of types of measures of aggression (e.g., murder and rape), historical time periods (early 1800s to the present), and cultures that have yielded essentially the same effects makes such alternative explanations rather implausible. For instance, the temperature-related year effect observed by Anderson (1987) essentially rules out the vacation explanation. Similarly, Rotton and Frey's (1985) finding of increased family disturbances in the hot summer months also contradicts the social contact hypothesis, because the frequency and intensity of within-family contacts is presumably lowest in summer and highest in winter.

One additional recent study provides further evidence against the alternative explanation of seasonal social contact. Michael and Zumpe (1986) designed a study in response to criticisms of their earlier work on temperature effects on assault and on rape frequency (Michael & Zumpe, 1983, discussed earlier). The alternative explanations were that assaults and rapes

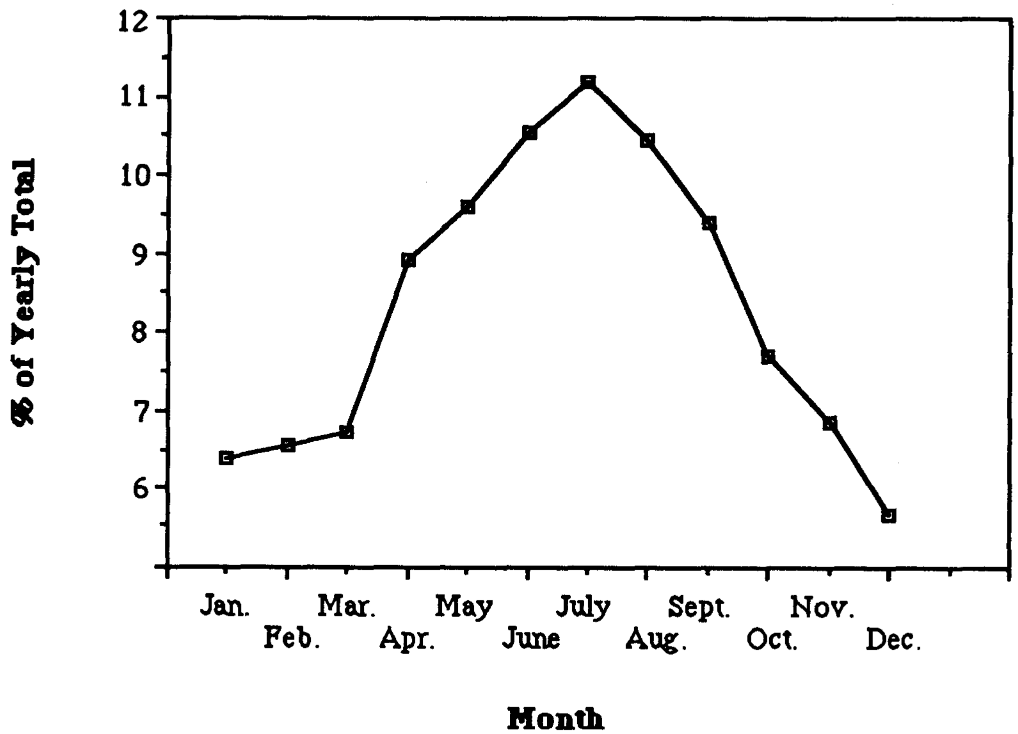

Figure 4. Monthly distribution of rapes. (These averages are based on data from Amir, 1971, Aschaffenburg, 1903/1913, Hayman et al., 1972, Lombroso, 1899/1911, Michael and Zumpe, 1983, and Perry and Simpson, 1987.)

may occur more frequently in the warmer months because of more frequent contact among potential victims and perpetrators (i.e., people get out more in summer) and because of "women's scantier clothing" being provocative. Michael and Zumpe (1986) reasoned that if these alternative explanations were true, then frequency of wife battering should not show the typical summer increase. In fact, one could argue that wife battering should go down, because 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 should be obtained.

To test these alternatives, Michael and Zumpe (1986) obtained the frequency of 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). For three of the locations (Atlanta, Texas, and Oregon) the primary dependent variable was the number of crisis calls. For Wyoming the measure was the number of women given shelter. For Sacramento the measure was number of requests for shelter. In each location the temperature distributions also were obtained.

Analyses of these data were done by the cosinor method described earlier. In each location the annual rhythm maximum was significant and occurred in either July or August (*p*s < .025). In each case the pattern of monthly abuse means corresponded very closely to the 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, it was pointed out that the photoperiod maxima (another alternative to the temperature interpretation) in these locations did not show this 40-day difference. Hence, the temperature interpretation seems to be the only plausible one left. Figure 6 presents the aggregated results from Michael and Zumpe's (1986) wife-beating studies. As can be seen, the monthly distribution of wife battering strongly supported the temperature–aggression hypothesis.

Effects of Hot Days

Two basic methodological approaches have been used in studies of the effects of hot days. In the first approach one computes the average daily incidence of a particular type of aggressive behavior for each of several temperature ranges. That is, for each temperature range (e.g., 0 °–4 °F, 5 °–9 °F, etc.) one divides the frequency of aggressive acts that took place on days in that range by the number of days in that range. Various kinds of bivariate analyses may be performed on such data. The temperature–aggression hypothesis specifies that these means (or conditional probabilities) should get larger at high temperature ranges.

In a previous section, Dexter's (1899) New York City assault data were analyzed by month. From Dexter's tables it also was possible to estimate the average daily assault rate for each of 18 5 ° temperature intervals (i.e., 0 ° to 5 °F through 85 ° to 90 °F). Note that Dexter recorded average daily temperatures rather

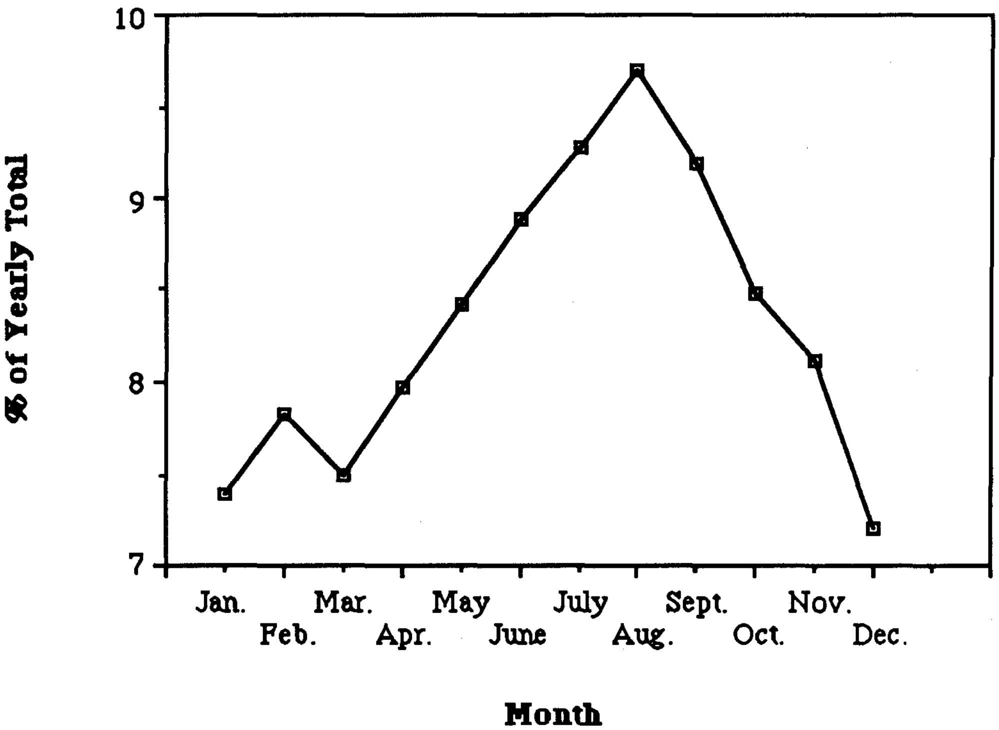

Figure 5. Monthly distribution of miscellaneous aggressive crimes. (These averages are based on data from Aschaffenburg, 1903/1913.)

than maximum daily temperatures.[5] I performed a set of weighted regression analyses testing the linear, quadratic, and cubic components of the temperature effect on assault rate, weighted by the number of days represented by each temperature category. There was a highly significant linear effect of temperature, with more assaults occurring on hotter days, $F(1, 16) = 64.52$, $p < .0001$. Furthermore, the effect of temperature on assault rates was fairly flat at low temperatures (up to about 50 ° to 60 ° average daily temperatures) but increased rapidly beyond that point, as is shown by the significant quadratic effect, $F(1, 15) = 11.25$, $p < .001$. These two components accounted for most of the variance in assault rates ($R^2 = .89$). There was no hint of a cubic effect ($F < 1$). The basic function relating assaults to temperatures was J shaped. As was pointed out earlier, the fact that coldness is more easily adapted to than hotness means that this J-shaped function could be consistent with theories specifying a linear function or a U-shaped function (i.e., the simple negative affect model, excitation transfer theory, cognitive neoassociationism model). These results are fairly strong contradictions to the negative affect escape model, though, because aggression did not show a significant drop at the higher temperature ranges.

Another study using this approach was one by Carlsmith and Anderson (1979). These researchers examined the relation between temperature (5 ° intervals) and likelihood of a riot in the United States from 1967 to 1971. A similar weighted regression analysis yielded both a significant linear effect of temperature, $F(1, 20) = 49.93$, $p < .0001$, and a quadratic effect, $F(1, 19) = 8.20$, $p < .01$ ($R^2 = .80$). There was no cubic effect ($F < 1$). Once again, the basic function relating the two variables was J shaped. These results also contradict the Baron and Bell negative affect escape model and are consistent with the other three models.

The final study of this type was the previously described Harries and Stadler (1983) study of assault in Dallas during 8 months of 1980 (March–October). These researchers computed a "discomfort index" based (essentially) on temperature and humidity for each day in that period. Days were then classified into one of five levels of discomfort, and ANOVAS were performed on the frequency-of-assault measure. The effect of temperature (discomfort) was as expected. The assault rate was highest at the hottest interval ($p < .0001$). Tests of the linear and quadratic effects of temperature were not possible, because the five levels of the discomfort index were only ordinal level.

The second approach to studying the effects of hot days is particularly useful when there typically are several occurrences of the target aggressive act each day. For each day the number of occurrences and the temperature are recorded. Regression analyses across days (rather than temperature intervals) can be used to examine the temperature–aggression hypothesis. This procedure is a bit more powerful than the temperature-interval procedure.

Rotton (1982) examined the daily frequency of rape in Dayton, Ohio, for a 2-year period. A variety of air pollution and climatological variables were assessed. The two main findings of interest here were (a) that temperature correlated signifi-

[5] Numerous scholars have used several different indexes of daily temperature, including temperature/humidity comfort indexes. The general finding is that all produce essentially the same results. Because they are so highly intercorrelated in naturalistic settings, attempts to show that one is superior to others in predicting aggression usually fail.

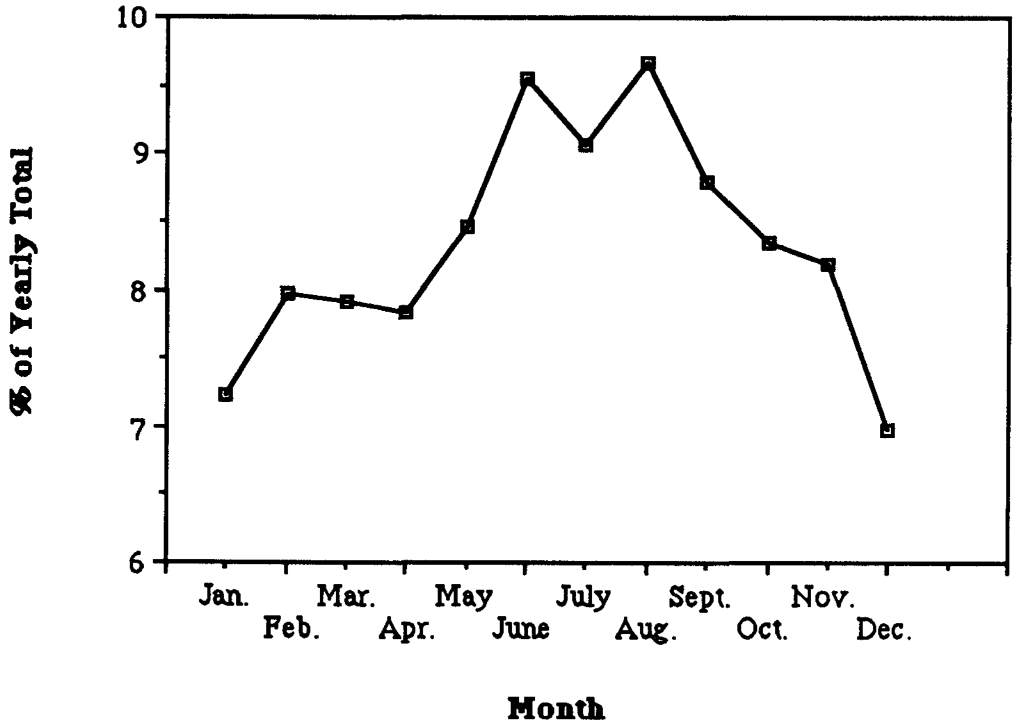

Figure 6. Monthly distribution of wife battering. (These averages are based on data from Michael and Zumpe, 1986.)

cantly with rape ($r = .16$, $p < .05$) and (b) that the quadratic effect of temperature did not approach significance, contradicting inverted-U–shaped models.

In addition to the seasonal effects reported earlier, Rotton and Frey (1985) also examined temperature effects on assaults and family disturbances at the level of days. Family disturbances and assaults were more prevalent on hotter than on cooler days ($ps < .01$). Furthermore, there was a significant quadratic effect of temperature on frequency of family disturbances. The form of this effect was J shaped; the effects of increasing temperatures on family disturbances were especially pronounced at the higher temperature levels. This shape again contradicts the negative affect escape model and supports the other major models. Also note that this effect on family disturbances provides further evidence that the social contact hypothesis cannot explain the temperature–aggression relation. Specifically, within-family contacts are more frequent and intense in colder weather. Thus, if the social contact hypothesis is correct, then family disturbances should decrease as temperatures increase; clearly, they do not.

Three studies have examined the relation between daily violent crime frequencies and temperature during summer months. By restricting the sample to summer months, these studies restricted the range of temperatures and therefore reduced the probability of finding significant relations. On the other hand, discovery of reliable temperature–aggression relations under these conditions is quite convincing.

Cotton (1986) examined the effects of daily temperature (and humidity, which did not significantly improve predictability) on violent crime in two separate studies. In the first he examined violent and nonviolent crime in Des Moines, Iowa, during July and August 1979. Results revealed that frequency of violent crime was positively related to temperature ($p < .05$), whereas nonviolent crime was not. Furthermore, the temperature effect was essentially linear.

In his second study, Cotton (1986) examined daily temperature effects on violent and nonviolent crime in Indianapolis during June, July, and August of 1978 and 1980. Once again, frequency of violent crime correlated significantly with temperature ($p < .02$), whereas nonviolent crime frequency did not. Cotton further reported that the effect appeared linear.

The final "restricted range" study was reported by Anderson and Anderson (1984, Study 1).[6] Average daily temperatures and frequency of criminal assaults were compared across 90 days in June, July, and August 1977 in Chicago. In addition, the effects of day of week were partialed out before effects of temperature were tested. The regression analysis revealed that temperature was linearly related to assault frequency ($p < .005$). There was no evidence of a curvilinear effect.

A study by Anderson and Anderson (1984, Study 2) examined daily temperature effects over a 2-year period in Houston, thus covering a broader range of temperatures than the restricted-range studies. The daily frequencies of violent crime (murder and rape) and nonviolent crime (robbery and arson) were compared to the daily maximum temperatures. The use of data from Houston allowed strong tests of the temperature–aggression hypothesis because very hot days are quite common there. Examination of crimes distinguished by their level of vio-

[6] This was a reanalysis of data originally gathered and reported by Jones, Terris, and Christensen, 1979.

lence or aggressiveness allowed tests of the notion that temperature is particularly influential on the most aggressive types of behavior. As was expected, violent crime was positively and linearly related to temperature ($p < .005$). Nonviolent crime was not linearly related to temperature, and neither type of crime was curvilinearly related to temperature.

Summary

The time period studies yield an impressive array of support for the temperature–aggression hypothesis. The existence of direct effects was supported by yearly, quarterly, seasonal, monthly, and daily levels of analysis, for a wide variety of aggressive behaviors. In addition, several studies with wide-ranging temperature intervals discovered essentially the same J-shaped effect.

The original negative affect escape model received no support, because the predicted inverted-U–shaped function never occurred. Several explanations of this failure are plausible. Obviously, the model may be wrong in assuming that escape motives increase faster than aggressive motives as negative affect intensifies. Alternatively, escape from the situations may have been difficult in each of these field studies, leaving aggression as the dominant behavioral possibility. This seems unlikely, because in most cases of assault, murder, and rape, the perpetrator can remove himself or herself from the situation. A third possibility is that the crucial inflection point in the inverted-U–shaped negative affect function was never reached. This also seems unlikely. Houston, for instance, is noted for its extremely uncomfortable summers, its air pollution, traffic jams, and other big city problems, all of which should push the populace well beyond the inflection point even at moderate temperatures.

The final possibility is that extremely hot days did not produce a downturn in aggression because during most hot days there is a cooler period of time that may be on the high-aggression side of the inflection point. Perhaps the aggressive motivation was instigated during that time. The major objection to this alternative is that in several locations tested in the previously cited studies (e.g., Houston, Dallas), the hottest days in fact had few cool periods, and those were in the early morning hours when few people were awake and aggressing. Perhaps the best response to this last explanation of the failure to find a downturn in aggression at the highest temperatures is to examine the temperature and the aggressive acts concomitantly.

Concomitant Temperature

In the previous sections it has been assumed that increases in aggression during hotter periods of time resulted from increases in aggression motivation caused by the uncomfortably hot temperatures that occurred sometime within the relevant time period. This assumption is not an unreasonable one given the cognitive capacity of humans to remember and reexperience annoyance, anger, and frustration well beyond the time in which such thoughts and feelings were first aroused. Most people have had the experience of a bad day at work carrying over to influence interpersonal interactions at a later time with other people, such as spouses and children. Similarly, increases in aggressive tendencies due to hot temperatures surely persist over at least short time periods, such as hours.

In this section I review studies that do not assume any time period duration; temperature and aggression variables were assessed concomitantly. Another general difference is that the concomitant studies tend to be conducted in laboratory settings. This is true of all but two of the concomitant studies. The obvious advantage of laboratory-based concomitant studies is that the researchers have experimental control over the temperature. The major disadvantage is that people in laboratories may not react in the same way as people who do not know they are being studied. These problems have been discussed previously in the context of the temperature–aggression hypothesis (e.g., Anderson & Anderson, 1984; Carlsmith & Anderson, 1979; Rule & Nesdale, 1976) and are mentioned only briefly here. First, subjects have strong prior social theories linking hot temperatures and increased aggression. Thus, in any laboratory study of temperature and aggression, a high portion of subjects are likely to guess or be suspicious about the true purpose of their tasks. Depending on how subjects react to these suspicions, the result may be artifactual support for or contradiction of several versions of the temperature–aggression hypothesis.

Second, unusual temperatures may induce in subjects cognitive processes that short-circuit the normal temperature–aggression linkage, even in the absence of concerns about self-presentation. For instance, a subject entering a hot lab room in a normally comfortable building will likely note the unusual temperature. On being insulted by a confederate, the subject may excuse the provocation by thinking that the confederate has been adversely affected by the temperature and may therefore show unusually low levels of aggression.

A third potential artifact was recently brought to my attention by J. Rotton (personal communication, March 1988). High levels of arousal and stress are distracting and may overload people's capacity to attend to other stimuli (e.g., Kahneman, 1973; Rotton, Olszewski, Charleton, & Soler, 1978). Thus, under high temperatures, subjects may devote less attention to a variety of stimuli including an insulting confederate.

These points are important to keep in mind while examining the concomitant studies. The inconsistency of results in these studies may be due to such artifacts.

Concomitant Aggression in the Lab

In the earliest study of this type, Baron (1972) had subjects deliver shocks to a confederate in a standard teacher/learner paradigm (e.g., Buss, 1961). Subjects previously had received either positive or negative evaluations from the confederate. All this took place under either comfortable or hot room conditions. Contrary to the temperature–aggression hypothesis, subjects in the cool conditions delivered significantly longer shock bursts than did those in the hot conditions ($p < .05$). The most plausible explanation of these results is that subjects in the hot conditions realized that their aggressive tendencies were being tested and responded by demonstrating low levels of aggression. That is, there was a differential awareness problem, with those in the hot conditions being most likely to realize that their aggression behavior was being studied. There are no data available, though, to test this or other alternative explanations.

Baron and Bell (1975) used a similar paradigm to study the effects of temperature (hot vs. cool), provocation (angry vs. not angry), and presence of an aggressive model (model vs. no model). The rationale for delivering shock to the confederate was changed from the teacher/learner paradigm to one involving physiological reactions to shock. The main finding of interest was a significant Temperature × Anger interaction ($p < .005$). Hot subjects delivered more shock in the nonangry conditions than did cool nonangry subjects ($p < .005$), but cool subjects who were angry delivered more shock than did hot angry subjects ($p < .05$). This Temperature × Anger interaction was replicated by Baron and Bell (1976, Study 1; $p < .025$). Note that this interaction contradicts the results of Baron (1972), who found that hot temperatures decreased aggression among nonangry as well as angry subjects.

On the basis of these and other results, Baron and Bell (1975) developed and later expanded their inverted-U–shaped negative affect escape model that was described earlier in this article. Before moving on, it is important to note that the inverted-U–shaped model was not unequivocally supported by these early studies. Indeed, the inconsistency of results across studies argued against it.

One further implication of the model is that other factors that increase or decrease the total negative affect should change the effects of hot versus cool temperatures. Baron and Bell (1976, Study 2) provided the first test of this prediction, using their physiological effects-of-shock paradigm. They manipulated three factors: anger (positive or negative evaluation of the subject delivered by the confederate who later became the subject's target), temperature (cool vs. hot), and a drink (the subject was or was not offered lemonade). As in previous studies, a significant Temperature × Anger interaction occurred ($p < .03$). Hot nonangry subjects aggressed more than cool nonangry subjects, whereas as cool angry subjects aggressed more than hot angry subjects. The Baron and Bell inverted-U–shaped negative affect model predicts that giving subjects a cooling drink should reduce the negative affect sufficiently to change the inflection point and hence this Anger × Temperature interaction. Basically, a three-way interaction is predicted. This interaction was not reported, but sufficient information was available to reconstruct it. It did not approach significance.

A second study to test this model was conducted by Bell and Baron (1976), again using the cover story of physiological effects of shock. Subjects were angered or not angered by receiving negative or positive evaluations by the confederate, in hot or cool temperatures. On the basis of research indicating that people like others with similar attitudes more than those with dissimilar attitudes, supposed attitude similarity with the confederate was also manipulated. Negative affect was assessed and used as an independent variable in a between-groups trend analysis. Consistent with the inverted-U–shaped model, there was a significant quadratic trend ($p < .01$). Conditions that produced a moderate amount of negative affect also produced the most aggression. However, a postexperimental questionnaire provided evidence against the model. Specifically, one question asked subjects to indicate how anxious they had been for the experiment to end. This supposedly was the competing motive leading to a decrease in aggression at high negative affect levels; it should therefore yield the same between-groups effects. Although this item did correlate negatively with aggression ($p < .05$), it yielded no significant between-groups differences.

Bell and Baron (1977) also examined their negative affect model using the physiological effects-of-shock paradigm. Four levels of temperature were manipulated: cold (63 °–65 °F), cool (71 °–73 °F), warm (84 °–86 °F), and hot (92 °–94 °F). Crossing this was an anger manipulation based on a confederate's evaluation of the subject (positive vs. negative). On three measures of aggression (shock intensity, duration, and a composite) there were significant main effects of anger ($ps < .03$). Most importantly, the Temperature × Anger interactions were not significant.

Subjects also had rated their affect before and after receiving the confederate's evaluation. The average change in affect was computed for each group to test the inverted-U–shaped model. These change values were used in a between-groups trend analysis. Surprisingly, these changes did not differ across groups. A quadratic trend analysis with the change means as the independent variable was significant ($p < .05$), supposedly supporting the model. This change measure makes little sense in this context, though, so this analysis is irrelevant to the temperature–aggression hypothesis or to the Baron and Bell model. Other work shows that the temperature manipulation influences affect at the pretest (Bell & Baron, 1976). The change score essentially subtracts out the effects of the temperature manipulation on affect. Note also that Bell and Baron (1976) did not use this procedure to do their trend analysis but instead relied on the second affect measure taken after the evaluation manipulation.

One other research group examined the Anger × Temperature interaction. Palamarek and Rule (1979) manipulated temperature (hot vs. normal) and anger at the confederate (negative vs. neutral evaluations of the subject). Subjects later were allowed to choose between one of two tasks, either a short boring one or a longer one that allowed aggression against the confederate. This dependent variable pitted the motives of escape and aggression against each other. The only significant effect on this choice variable was an interaction ($p < .04$). Hot nonangry subjects and cool angry subjects were most likely to choose the aggressive task. Although this result supports the Baron and Bell model, other results cast doubt on this interpretation. First, self-ratings on desire to escape the situation yielded no significant effects; thus motivation to escape was not supported as a valid mediating variable. Second, when subjects rated the extent to which their mood was caused by the situation, the ratings paralleled the aggression choices. Specifically, those in the hot angry and the cool nonangry conditions attributed their mood more to the situation than did the other subjects. Perhaps they chose the less aggressive response because of this situational attribution. This attribution interaction was significant and could have accounted for the differences in aggression choices.

Bell (1980) provided the most recent test of the inverted-U–shaped model. Subjects were hooked up to physiological recording equipment in either a hot or a cool room, with loud or moderate noise, and were either angered or not angered by the experimenter. Later, all subjects completed three questions about that experimenter's performance, supposedly for evaluation by the university administration. Subjects could aggress against the first experimenter by giving him poor ratings, possibly costing him his job. The inverted-U–shaped model predicts that at low levels of overall negative affect (i.e., moderate noise, nonangry), hot temperatures should produce more aggression than cool temperatures. On the other hand, at high levels of overall negative affect (i.e., loud noise, angry), hot temperatures should produce less aggression than cool temperatures. One measure produced no reliable results. A second produced only a main effect of anger. The third measure produced only a Temperature × Anger interaction ($p < .05$) that was opposite in form to that predicted by the inverted-U–shaped negative affect model. Specifically, there was no effect of temperature on the nonangry subjects' ratings of the experimenter; but for angry subjects, those in the hot conditions displayed more aggression than those in the cool conditions. This latter finding is most consistent with the excitation transfer/misattribution of arousal model.

The final concomitant laboratory study was reported by Boyanowsky, Calvert, Young, and Brideau (1981–1982). Many of the most intriguing results were reported without means or inferential statistics. However, an earlier unpublished version of the article did contain more complete information (Boyanowsky, Calvert-Boyanowsky, Young, & Brideau, 1975). Boyanowsky et al. tested the hypothesis that uncomfortably cold temperatures as well as uncomfortably hot ones would increase aggression. In the first experiment the subject's task was to produce a series of floor plans. The subject's partner (a confederate) provided written feedback, which was negative. The subject then evaluated the partner's assessment by delivering from 1 to 10 electric shocks ("sensory feedback"). All this took place with the subject in either cold (50 °F), comfortable (68 °F), or hot (86 °F) conditions. Those in the cold and hot conditions delivered significantly more shocks than did those in the comfortable condition ($p < .01$).

In a second experiment a different initial task was used (subject's statements on five social issues). The partner gave either insulting (negative) or neutral verbal feedback to the subject, who then chose what level of shock to give the partner as sensory feedback. The subjects participated under cold, comfortable, or hot conditions. The main results were significant main effects of temperature and of insult. Hot and cold subjects delivered more shocks than did subjects at comfortable temperatures ($p < .05$). Insulted subjects delivered more shocks than did those who received neutral feedback ($p < .001$). The temperature effect was larger in the insult condition than in the neutral feedback condition, but this difference apparently was not reliable, because the overall interaction was reported to be nonsignificant.

A third experiment included two temperature levels, hot and cold. Crossing this factor was a three-level feedback factor; subjects received insulting feedback and had a large thermometer in plain sight, were insulted without a thermometer in sight, or were not insulted. Dependent measures included the number of shocks delivered to the confederate, heart rate, body temperature, and affective reactions toward the confederate. On the aggression measure all effects were significant, including the Temperature × Feedback interaction ($p < .01$). Briefly, making temperature a salient feature of the situation (i.e., the thermometer) reduced aggression in the hot conditions but not in the cold conditions. A similar pattern of results occurred on the measure of affect toward the confederate. In the hot insult conditions, the thermometer reduced negative feelings significantly ($p < .05$), whereas it failed to do so in the cold conditions ($F < 1$). The authors did not report the appropriate 2 × 2 (Insult and thermometer or insult and no thermometer × Hot or cold) interaction, but my calculations revealed it to be nonsignificant, $F(1, 54) = 1.6$.

A variety of other findings were reported. The ones of most interest here are that (a) heart rate was higher in the cold conditions than in the hot conditions; (b) heart rate tended to increase over trials in all cold conditions; (c) heart rate tended to increase over trials in the hot insult condition but decreased in the hot insult and thermometer condition and the hot no-insult condition; (d) in comparison with their respective no-insult subjects, hot and cold insult subjects displayed increases in core temperatures over trials, whereas insulted subjects with a thermometer in sight did not.

Overall, these results support the excitation transfer/misattribution of arousal model. Specifically, negative arousal deriving from hot temperatures (as shown by changes in heart rate and core temperatures) may somehow get added to aggression arousal when the manipulation is subtle. The addition of a thermometer makes subjects aware that their annoyance is at least partly caused by hot temperatures. This is, after all, a firmly entrenched social theory in our culture. This reattribution process in turn may yield less anger and less aggression toward the insulting confederate. The lack of comparable results in the cold conditions probably was caused by the lack of a salient cold–aggression social theory, without which the necessary misattribution could not be made.

One final comment about the increase in aggression created by the cold temperatures concerns the failure to see similar increases in the regional and the time period studies. As was discussed earlier, there is a major asymmetry between hot and cold temperatures in naturalistic settings. One can keep warm by adding more clothing, and heating systems are generally available. However, there is relatively little one can do to avoid uncomfortably hot temperatures. To be sure, air-conditioning is more readily available than in the past. Indeed, the Harries et al. (1984) finding of a smaller summer increase in aggression in neighborhoods with air conditioning supports the temperature–aggression hypothesis. But sufficient cooling is considerably rarer than sufficient heating. In addition, when one must be outside in uncomfortable weather, it is easier to keep warm in cold weather than it is to keep cool in hot weather. These comments are admittedly speculative, but the idea that negative affect induced by being cold may increase aggression warrants further research.

On the whole, these laboratory studies of concomitant temperature–aggression effects yield more confusion than understanding. Sometimes hotter conditions led to increases in aggression; at other times the opposite occurred. Most of the studies were by the same researchers using the same general paradigm, yet even this did not result in consistency in findings across studies. The Anger × Temperature interaction sometimes occurred and sometimes did not. When it did occur, it usually took the form of a positive temperature effect (increased heat, increased aggression) in nonangry conditions and a negative temperature effect in angry conditions. In at least one instance the form was opposite. Furthermore, the dominant model designed to explain these results, the negative affect escape model, seldom was supported. The best explanation for all these problems is not a very satisfactory one. But it seems that there are a number of methodological artifacts in these studies, based primarily on subject's intuitive social theories about heat and aggression and on the unusualness of the laboratory conditions and manipulations. I see no easy way around these problems; if there were any, I have no doubt that the scholars involved would have found them by now. But the results from these studies are clearly at variance with the uniformly positive results of the region and time period studies, as well as being internally inconsistent. The best suggestion at this point seems to be the always trite but often true statement that more research is needed. The Boyanowsky et al. (1981–1982) approach seems quite promising.

Naturalistic Aggression

One solution to the methodological problems introduced by these laboratory studies is to move out of the lab. If people are not aware that they are subjects of study, their impression-management concerns cannot distort the findings, and their social theories about heat and aggression are less likely to be salient. Indeed, that is the chief strength of the geographic region and time period studies reviewed earlier. It is also possible to perform concomitant studies in naturalistic settings. Only two such studies have been reported.

Baron (1976) studied the influence of several incompatible reactions to aggression as a means of reducing it. Passing motorists were delayed by a confederate whose car sat through a green light. The dependent measure of aggression was latency to horn honking. The study was conducted when the temperatures were in the mid-80 °F range. Furthermore, subjects were classified as having air-conditioned or unair-conditioned cars. Those without air-conditioning presumably would be uncomfortably warm. The main finding of interest here was that subjects without air-conditioning honked their horns sooner than those with air-conditioning. This study supports the temperature–aggression hypothesis in that hot subjects aggressed sooner than cool subjects. However, because horn honking in these conditions may be seen as especially instrumental for those without air-conditioning, the relevance to the temperature–aggression hypothesis is questionable.

The second study of this type also investigated horn honking in response to a confederate blocking an intersection (Kenrick & MacFarlane, 1984). These researchers, though, used several different measures of horn honking, some of which were equally instrumental for all subjects. Specifically, they assessed latency to honk, number of honks, and total time spent honking. The latter two measures are not differentially instrumental as a function of temperature or as a function of air-conditioning. In both cases, once one has honked the horn the instrumental role of further honking is negligible. Because the 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 in the spring and summer; temperatures ranged from 84 ° to 108 °F. The temperature–aggression hypothesis predicts greater horn honking at greater temperatures, especially by those subjects in cars without air-conditioning. This paradigm is a better test of the hypothesis than the reviewed concomitant laboratory studies because competing motives, such as escape from the situation, do not come into play. As was 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 ($r = .12$; $Z = 2.54$, $p < .02$). There was no hint of a quadratic effect, nor did addition of humidity add significantly to the prediction of horn honking.

Overall, the concomitant studies yield a confusing picture. The study with the fewest methodological problems (Kenrick & MacFarlane, 1984) supported the general conclusion of the geographic region and time period studies: Uncomfortably hot temperatures increase the motive to aggress. The negative affect escape model was strongly contradicted in several studies by a failure to get decreases in aggression at high temperatures even when additional sources of negative affect were present. Even in the several studies that found such decreases, other measures failed to confirm the role of escape motives and suggested that artifactual processes (such as attributing one's mood to the hot situation) were at work.

Attraction, Affect, and Thought

A number of studies have examined the effects of concomitant temperature variations on variables believed to be related to aggression. Uncomfortably hot temperatures may increase aggression by decreasing interpersonal attraction or evaluations, by increasing negative affect, and by increasing aggressive thoughts. It is not clear what temporal sequence or causal linkages, if any, exist among these types of variables. Does general negative affect set in first, leading to interpersonal evaluation effects and to aggressive thoughts? Or does high temperature lead to aggressive thoughts, which in turn influence interpersonal evaluations and general affect? Or are these three classes of variables essentially independent? No research has investigated the relatedness of these variables in the temperature–aggression domain. However, a number have looked at the effects of temperature manipulations on each type of variable.

Attraction. Two widely cited papers by Griffitt (1970; Griffitt & Veitch, 1971) reported studies finding that hot temperatures influenced attraction to strangers. In the first study, subjects examined a stranger's responses to a 44-item attitude scale under comfortable or hot conditions. The stranger's responses were rigged such that they agreed with the subject 25% or 75% of the time. Later, subjects rated the stranger on several dimensions and rated their own affect. Subjects gave more negative attraction responses under hot than under normal conditions ($p < .04$). This effect did not interact with the attitude similarity manipulation ($p > .25$).

Griffitt and Veitch (1971) used the same basic paradigm with the addition of a third experimental factor, that of crowding during the experiment. Subjects in the hot conditions tended to give more negative attraction ratings than did subjects in the normal temperature conditions. However, the effect was only marginally significant ($p < .07$).

Only two other studies have examined the temperature–attraction relation; both failed to replicate the effect. Bell and Baron (1974) factorially manipulated temperature (hot vs. normal), attitude similarity (similar vs. dissimilar), and personal evaluation by the confederate (positive vs. negative). Using the same attraction index used by Griffitt (1970; Griffitt & Veitch, 1971), Bell and Baron found the same pattern of lowered attraction ratings under high temperature, but this effect did not approach significance ($p > .25$).[7] Bell, Garnand, and Heath (1984)

[7] This test was not reported by Bell and Baron (1974) but was computed from information presented in their article.

had same-sex pairs of subjects perform a variety of tasks under either hot or cool (normal) conditions, seated either across from each other or side by side. Subjects later made attraction ratings on the same scales used in previously described studies. Though no statistical tests were reported for temperature effects on attraction, the authors noted that there were no significant effects.

Affect. Numerous studies have assessed general and specific affects (moods) under different temperature conditions. The results of these studies are quite consistent; people report being more uncomfortable and in worse moods under hot than under cool conditions. For example, Griffitt (1970; described previously) showed that hot subjects had more negative general moods and felt less elated, more fatigued, and less vigorous than cool subjects ($ps < .05$). Griffitt and Veitch (1971) replicated these effects with general mood ($p < .001$) as well as with a variety of specific moods. In addition, their hot condition subjects rated the experimental room as more unpleasant and uncomfortable and the experiment itself as more unpleasant than did cool condition subjects ($ps < .001$). Finally, note that in both of these studies, attraction ratings correlated significantly (though lowly) with a variety of the affect measures. Subjects experiencing greater negative affect tended to give lower attraction ratings.

Bell and Baron's (1974) study of temperature and attraction also assessed general affective reactions. They found that hot subjects reported more negative affect than did cool subjects ($p < .005$). Bell et al. (1984) replicated this temperature affect finding ($p < .01$).

Two of the laboratory studies on concomitant temperature–aggression effects (reviewed earlier) also reported subjects' ratings of affect or comfort. The effects in these studies were quite consistent. Baron and Bell (1975) reported that subjects in the hot conditions rated the experimental rooms as less pleasant and less comfortable than did those in the cool conditions ($ps < .001$). Baron and Bell (1976) reported that the hot subjects in both of their experiments experienced greater discomfort than the cool subjects ($ps < .05$).

Thought. Only one study has investigated the effects of temperature on subjects' thought content. Rule, Taylor, and Dobbs (1987) had subjects read and complete story stems under cool (normal) or hot conditions. Some of the story stems were aggression relevant, whereas others were more neutral in content. Content analyses on the completions revealed an interesting interaction. A greater proportion of the subjects' completions were classified as aggressive in the hot condition in comparison with the cool condition, but only for the aggression-relevant story stems. Thus, it appears that hot temperatures can prime aggressive thoughts, at least when the situation is somewhat aggression relevant.

At first glance this study appears to support the cognitive neoassociation model. However, as was pointed out earlier, this model predicts that hot temperatures should prime aggressive thoughts in aggression-neutral conditions as well. The failure to get such a priming effect in the neutral conditions suggests that an aggressive cue must be present. This is more in line with an excitation transfer version of cognitive neoassociation. Although no link between primed aggressive thoughts and actual aggression motives or behaviors has been tested, these two versions of the cognitive priming approach to the temperature–aggression relation both appear promising.

Conclusions

Basic Issues

Of the three basic issues outlined at the beginning of this article, only that concerning the existence of direct effects of temperature on aggression has received sufficient empirical attention to warrant a conclusion. Clearly, hot temperatures produce increases in aggressive motives and tendencies. Hotter regions of the world yield more aggression; this is especially apparent when analyses are done within countries. Hotter years, quarters of years, seasons, months, and days all yield relatively more aggressive behaviors such as murders, rapes, assaults, riots, and wife beatings, among others. Finally, those concomitant temperature–aggression studies done in the field also yielded clear evidence that uncomfortably hot temperatures produce increases in aggressive motives and behaviors.

The only inconsistent evidence concerning the existence of such temperature effects came from laboratory studies. Normally, the failure of experimental laboratory studies to replicate correlational findings from the field would suffice to convince me (and I assume most other experimentally trained psychologists) that there exists some universal confound in the field studies that is artifactually producing the obtained effects. There are two reasons why such faith in the experimental method fails to produce such a reaction here. First, the field studies yielded consistent results across an amazing range of levels of analysis (e.g., geographic regions, time periods), locales (e.g., Europe, United States), historical time periods (e.g., 1800s, 1980s), and dependent variables (e.g., homicide, horn honking). Second, the laboratory studies themselves suffer from several necessarily reactive conditions that call into question their internal validity. Specifically, uncomfortably hot temperatures become the "figure" in the lab, whereas they are "ground" in the field. When in combination with people's generally strong social theories relating temperature to aggression, this salience of temperature likely produces artifactual reactions in laboratory subjects. To be sure, the inconsistencies of the laboratory studies is disquieting and should not be entirely dismissed. Discovery or creation of procedures that allow experimental investigation of temperature–aggression phenomena should be a top priority in future research; it is vital to testing more specific research questions that are currently unanswered.

The remaining two basic issues have not been cleanly addressed by the currently available research. The shape of the temperature–aggression relation appears to be that of a J or U, but better data are needed to confirm or correct this tentative conclusion. Of the five models outlined at the beginning, only the negative affect escape model has received much empirical attention. The bulk of the studies strongly contradicted this model, even when the necessary conditions (e.g., possibility of escape from the situation) were explicitly built into the design.

Although the remaining models have not been adequately tested, the existing studies provide some hints. The simple negative affect model was supported by studies finding increased aggression both when subjects were made uncomfortably hot and when they were made uncomfortably cold (e.g., Boyanowsky et al., 1981–1982). However, studies showing that cognitive/attributional processes may be involved, such as the Rule et al. (1987) thought-priming study and the Boyanowsky et al.

(1981–1982) thermometer study, suggest that a more complex model incorporating cognitive effects is needed. The cognitive neoassociation model has received little attention but appears to be contradicted by the Rule et al. (1987) finding that hot temperatures primed aggressive thoughts only when aggression cues were present. The physiological–thermoregulatory model simply has not been tested. The major impediment to testing this model is the complexity of both thermoregulatory and aggression systems.

Finally, although the excitation transfer/misattribution of arousal model can account for all the results presented in existing studies, including the mixed results of the laboratory studies, it can do so only if assumptions about misattributions of arousal are made. Until explicit tests of the model are made, support for it must be seen as indirect and speculative.

Future Work

The massive body of work reviewed in this article demonstrates two main points. First, temperature effects are direct; they operate at the individual level. Second, temperature effects are important; they influence the most antisocial behaviors imaginable.

At the most general level, future work needs to attend to four nonexclusive features. First, more controlled field studies are needed. By this I mean studies in which the more plausible potential confounds are assessed and controlled. This would include field experiments and quasi-experiments as well as correlational studies. The main advantage of this type of study is that it would allow temperature variations to remain in the background rather than to figure prominently in the subjects' attention.

Second, nonreactive laboratory experiments are needed. It is not clear how to do this, but some combination of more subtle manipulations of temperature and assessments of aggression may prove valuable. Furthermore, one can assess subjects' suspicions to see how successful the staging has been and to see if suspicions influenced aggression.

Third, researchers' attention must be directed toward the underlying processes. The supposed mediators of the temperature effects must be assessed and manipulated and the results compared to the theories of temperature effects. More attention to the effects of cold will further theoretical development. Detailed measurement of a variety of physiological effects would aid the construction of better physiological–thermoregulatory models. Misattribution manipulations, extraneous arousal manipulations, and assessment of delayed effects of temperature manipulations would allow tests of various cognitive and misattribution models.

The results of such studies will not only improve our understanding of aggression but should also prove useful in reducing unwarranted human aggression. For example, if an excitation transfer/misattribution model is supported in future work, it may be possible to create appropriate reattribution therapies for those who tend to aggress primarily when hot. This may apply to some portion of wife beaters, for instance, and may be incorporated as part of a broader therapy designed to reduce such behaviors. Similarly, increasing awareness at a societal level of the large impact that uncomfortable temperatures have on one's own and others' affective states and behaviors may yield greater tolerance for others' seemingly unwarranted provocations and greater willingness to control one's own aggressive tendencies. Finally, a better understanding of temperature effects on aggression may result in changes in environmental standards in various institutions. For example, it may be more cost-effective (as well as humanitarian) to cool prison environments as a means of reducing inmate violence rather than to increase the supervision and segregation of prisoners. Taking such practical steps now seems a bit premature. However, with a better understanding of the theoretical processes underlying temperature–aggression phenomena such practical interventions could be implemented effectively.

References

Amir, M. (1971). *Patterns in forcible rape.* Chicago: University of Chicago Press.

Anderson, C. A. (1987). Temperature and aggression: Effects on quarterly, yearly, and city rates of violent and nonviolent crime. *Journal of Personality and Social Psychology, 52,* 1161–1173.

Anderson, C. A., & Anderson, D. C. (1984). Ambient temperature and violent crime: Tests of the linear and curvilinear hypotheses. *Journal of Personality and Social Psychology, 46,* 91–97.

Aschaffenburg, G. (1903/1913). *Crime and its repression.* Boston: Little, Brown.

Baron, R. A. (1972). Aggression as a function of ambient temperatures and prior anger arousal. *Journal of Personality and Social Psychology, 21,* 183–189.

Baron, R. A. (1976). The reduction of human aggression: A field study of the influence of incompatible reactions. *Journal of Applied Social Psychology, 6,* 260–274.

Baron, R. A. (1979). Aggression and heat: The "long hot summer" revisited. In A. Baum, J. E. Singer, & S. Valins (Eds.), *Advances in environmental psychology* (pp. 57–84). Hillsdale, NJ: Erlbaum.

Baron, R. A., & Bell, P. A. (1975). Aggression and heat: Mediating effects of prior provocation and exposure to an aggressive model. *Journal of Personality and Social Psychology, 31,* 825–832.

Baron, R. A., & Bell, P. A. (1976). Aggression and heat: The influence of ambient temperature, negative affect, and a cooling drink on physical aggression. *Journal of Personality and Social Psychology, 33,* 245–255.

Bazett, H. C. (1927). Physiological responses to heat. *Physiological Reviews, 7,* 531–599.

Bell, P. A. (1980). Effects of heat, noise, and provocation on retaliatory evaluative behavior. *Journal of Social Psychology, 110,* 97–100.

Bell, P. A., & Baron, R. A. (1974). Environmental influences on attraction: Effects of heat, attitude similarity, and personal evaluations. *Bulletin of the Psychonomic Society, 4,* 479–481.

Bell, P. A., & Baron, R. A. (1976). Aggression and heat: The mediating role of negative affect. *Journal of Applied Social Psychology, 6,* 18–30.

Bell, P. A., & Baron, R. A. (1977). Aggression and ambient temperature: The facilitating and inhibiting effects of hot and cold environments. *Bulletin of the Psychonomic Society, 9,* 443–445.

Bell, P. A., Garnand, D. B., & Heath, D. (1984). Effects of ambient temperature and seating arrangement on personal and environmental evaluations. *Journal of General Psychology, 110,* 197–200.

Berkowitz, L. (1983a). Aversively stimulated aggression: Some parallels and differences in research with animals and humans. *American Psychologist, 38,* 1135–1144.

Berkowitz, L. (1983b). The experience of anger as a parallel process in the display of impulsive, "angry" aggression. In R. Geen & E. Donnerstein (Eds.), *Aggression: Theoretical and empirical reviews: Vol. 1* (pp. 103–133). New York: Academic Press.

Berkowitz, L. (1984). Some effects of thoughts on anti- and prosocial influences of media events: A cognitive-neoassociation analysis. *Psychological Bulletin, 95,* 410–427.

Blanchard, D. C., & Blanchard, R. J. (1984). Affect and aggression: An animal model applied to human behavior. In R. J. Blanchard & D. C. Blanchard (Eds.), *Advances in the study of aggression: Vol. 1* (pp. 1–62). Orlando, FL: Academic Press.

Bligh, J. (1973). *Temperature regulation in mammals and other vertebrates.* New York: American Elsevier.

Bloch, G. (1985). *Body & self: Elements of human biology, behavior, and health.* Los Altos, CA: Kaufman.

Boyanowsky, E. O., Calvert-Boyanowsky, J., Young, J., & Brideau, L. (1975). *In the heat of passion and in cold blood: Patterns of aggressive behavior.* Unpublished manuscript, Simon Fraser University, Burnaby, British Columbia, Canada.

Boyanowsky, E. O., Calvert, J., Young, J., & Brideau, L. (1981–1982). Toward a thermoregulatory model of violence. *Journal of Environmental Systems, 1,* 81–87.

Brain, P. F. (1984). Biological explanations of human aggression and the resulting therapies offered by such approaches: A critical evaluation. In R. Blanchard & D. Blanchard (Eds.), *Advances in the study of aggression: Vol. 1* (pp. 63–102). New York: Academic Press.

Brearley, H. C. (1932). *Homicide in the United States.* Montclair, NJ: Patterson-Smith.

Buss, A. H. (1961). *The psychology of aggression.* New York: Wiley.

Campbell, D. T., & Fiske, D. W. (1959). Convergent and discriminant validation by the multitrait–multimethod matrix. *Psychological Bulletin, 56,* 81–105.

Carlsmith, J. M., & Anderson, C. A. (1979). Ambient temperature and the occurrence of collective violence: A new analysis. *Journal of Personality and Social Psychology, 37,* 337–344.

Cerbus, G. (1970). Seasonal variation in some mental health statistics: Suicides, homicides, psychiatric admissions, and institutional placement of the retarded. *Journal of Clinical Psychology, 26,* 60–63.

Chang, D. H. (1972). Environmental influences on criminal activity in Korea. *Criminology, 10,* 338–352.

Cohen, J. (1941). The geography of crime. *Annals of the American Academy of Political and Social Science, 217,* 29–37.

Cotton, J. L. (1986). Ambient temperature and violent crime. *Journal of Applied Social Psychology, 16,* 786–801.

Crano, W., & Brewer, M. (1973). *Principles of research in social psychology.* New York: McGraw-Hill.

deFronzo, J. (1984). Climate and crime. *Environment and Behavior, 16,* 185–210.

Dexter, E. G. (1899). Conduct and the weather. *Psychological Monographs, 11*(10), 1–103.

Dodge, R. W., & Lentzner, H. R. (1980). *Crime and seasonality: National crime survey report* (Report No. SD-NCS-N-15). Washington, DC: U.S. Department of Justice.

Falk, G. J. (1952). The influence of the seasons on the crime rate. *Journal of Criminal Law & Criminology & Police Science, 43,* 199–213.

Feigl, H. (1958). The mental and the physical. In H. Feigl, M. Scriven, & G. Maxwell (Eds.), *Minnesota studies in the philosophy of science: Vol. II. Concepts, theories, and the mind-body problem.* Minneapolis: University of Minnesota Press.

Geen, R. G., & O'Neal, E. C. (1969). Activation of cue-elicited aggression by general arousal. *Journal of Personality and Social Psychology, 11,* 289–292.

Griffitt, W. (1970). Environmental effects on interpersonal affective behavior: Ambient effective temperature and attraction. *Journal of Personality and Social Psychology, 15,* 240–244.

Griffitt, W., & Veitch, R. (1971). Hot and crowded: Influences of population density and temperature on interpersonal affective behavior. *Journal of Personality and Social Psychology, 17,* 92–98.

Hardy, J. D. (1961). Physiology of temperature regulation. *Physiological Reviews, 41,* 521–605.

Harries, K. D., & Stadler, S. J. (1983). Determinism revisited: Assault and heat stress in Dallas, 1980. *Environment and Behavior, 15,* 235–256.

Harries, K. D., Stadler, S. J., & Zdorkowski, R. T. (1984). Seasonality and assault: Explorations in inter-neighborhood variation, Dallas, 1980. *Annals of the Association of American Geographers, 74,* 590–604.

Hayman, C. R., Lanza, C., Fuentes, R., & Algor, K. (1972). Rape in the District of Columbia. *American Journal of Obstetrics & Gynecology, 113,* 91–97.

Iskrant, A. P., & Joliet, P. V. (1968). *Accidents and homicide.* Cambridge, MA: Harvard University Press.

Jones, J. W., Terris, W., & Christensen, H. (1979, May). *Ambient temperature and the occurrence of serious criminal assault.* Paper presented at the annual convention of the Midwestern Psychological Association, Chicago.

Kahneman, D. (1973). *Attention and effort.* Englewood Cliffs, NJ: Prentice-Hall.

Kenrick, D. T., & MacFarlane, S. W. (1984). Ambient temperature and horn-honking: A field study of the heat/aggression relationship. *Environment and Behavior, 18,* 179–191.

Leffingwell, A. (1892). *Illegitimacy and the influence of the seasons upon conduct.* New York: Scribners.

Lester, D. (1979). Temporal variation in suicide and homicide. *American Journal of Epidemiology, 109,* 517–520.

Lombroso, C. (1899/1911). *Crime: Its causes and remedies.* Boston: Little, Brown.

McGrath, J. E., Martin, J., & Kukla, R. A. (1982). *Judgment calls in research.* Beverly Hills, CA: Sage.

Meyers, R. D. (1974). Neurochemical mechanisms of temperature regulation and food ingestion. In R. D. Myers & R. R. Drucker-Colin (Eds.), *Neurahumoral coding of brain function* (pp. 99–114). New York: Plenum Press.

Michael, R. P., & Zumpe, D. (1983). Annual rhythms in human violence and sexual aggression in the United States and the role of temperature. *Social Biology, 30,* 263–278.

Michael, R. P., & Zumpe, D. (1986). An annual rhythm in the battering of women. *American Journal of Psychiatry, 143,* 637–640.

Oken, D., Grinker, R. R., Heath, H. A., Herz, M., Korchin, S. J., Sabshin, M., & Schwartz, M. B. (1962). Relation of physiological responses to affect expression. *Archives of General Psychiatry, 6,* 336–352.

Olweus, D., Mattsson, A., Schalling, D., & Low, H. (1980). Testosterone, aggression, physical, and personality dimensions in normal adolescent males. *Psychosomatic Medicine, 42,* 253–269.

Palamarek, D. L., & Rule, B. G. (1979). The effects of ambient temperature and insult on the motivation to retaliate or escape. *Motivation and Emotion, 3,* 83–92.

Perry, J. D., & Simpson, M. E. (1987). Violent crimes in a city: Environmental determinants. *Environment and Behavior, 19,* 77–90.

Persinger, M. A. (1980). *The weather matrix and human behavior.* New York: Praeger.

Reinberg, A., & Lagoguey, M. (1978). Circadian and circannual rhythms in sexual activity and plasma hormones (FSH, LH, testosterone) of five human males. *Archives of Sexual Behavior, 7,* 13–30.

Reis, D. J. (1974). The chemical coding of aggression in brain. In R. Myers & R. Drucker-Colin (Eds.), *Neurahumoral coding of brain function* (pp. 125–150). New York: Plenum Press.

Robbins, M. C., DeWalt, E. R., & Pelto, P. J. (1972). Climate and behavior: A biocultural study. *Journal of Cross-Cultural Psychology, 3,* 331–344.

Rosenfeld, R. (1986). Urban crime rates: Effects of inequality, welfare, dependency, region, and race. In J. Byrne & R. Sampson (Eds.), *The social ecology of crime* (pp. 116–132). New York: Springer-Verlag.

Rotton, J. (1982, March). *Seasonal and atmospheric determinants of sex crimes: Time series analysis of archival data.* Paper presented at the annual convention of the Southeastern Psychological Association, New Orleans, LA.

Rotton, J. (1985, August). *Pedestrian movement in warm and cool settings.* Paper presented at the 95th annual convention of the American Psychological Association, Los Angeles.

Rotton, J. (1986). Determinism redux: Climate and cultural correlates of violence. *Environment and Behavior, 18,* 346–368.

Rotton, J., Barry, T., & Kimble, C. E. (1985, August). *Climate and violent crime: Coping with multicollinearity.* Paper presented at the 95th annual convention of the American Psychological Association, Los Angeles.

Rotton, J., & Frey, J. (1985). Air pollution, weather, and violent crimes: Concomitant time-series analysis of archival data. *Journal of Personality and Social Psychology, 49,* 1207–1220.

Rotton, J., Olszewski, D., Charleton, M., & Soler, E. (1978). Loud speech, conglomerate noise, and behavioral aftereffects. *Journal of Applied Psychology, 63,* 360–365.

Rule, B. G., & Nesdale, A. R. (1976). Environmental stressors, emotional arousal and aggression. In I. Sarason & C. Spielberger (Eds.), *Stress and anxiety: Vol. 3* (pp. 87–104). New York: Halstead Press.

Rule, B. G., Taylor, B. R., & Dobbs, A. R. (1987). Priming effects of heat on aggressive thoughts. *Social Cognition, 5,* 131–143.

Schwartz, D. C. (1968). On the ecology of political violence: "The long hot summer" as a hypothesis. *American Behavioral Scientist, 11*(July–August), 24–28.

Smals, A. G. H., Kloppenborg, P. W. C., & Benraad, T. J. (1976). Circannual cycle in plasma testosterone levels in man. *Journal of Clinical Endocrinology & Metabolism, 42,* 979–982.

Smolensky, M. H., Reinberg, A., Bicakova-Rocher, A., & Sanford, J. (1981). Chronoepidemiological search for circannual changes in the sexual activity of human males. *Chronobiologia, 8,* 217–230.

Tromp, S. W. (1980). *Biometeorology: The impact of the weather and climate on humans and their environment.* London: Heydon.

Uleman, J. S. (1987). Consciousness and control: The case of spontaneous trait inferences. *Personality and Social Psychology Bulletin, 13,* 337–354.

Zillmann, D. (1983a). Arousal and aggression. In R. Geen & E. Donnerstein (Eds.), *Aggression: Theoretical and empirical reviews: Vol. 1* (pp. 75–102). New York: Academic Press.

Zillmann, D. (1983b). Transfer of excitation in emotional behavior. In J. Cacioppo & R. Petty (Eds.), *Social psychophysiology: A sourcebook* (pp. 215–240). New York: Guilford Press.

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