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Ambient Temperature and Violent Crime: Tests of the Linear and Curvilinear Hypotheses

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Laboratory research on the effects of temperature has led theorists to propose a curvilinear model relating negative affect and aggression. Two alternative explanations of these lab findings are proposed—one artifactual, one based on attributions for arousal. Both alternatives predict a linear relationship between temperature and aggression in real-world settings, whereas the negative affect curvilinear model predicts a specific curvilinear effect. Two studies are reported that investigated the relationship between temperature and violent crime. Both studies yielded significant linear relationships and failed to demonstrate the specified curvilinear relationship. Also, both studies yielded significant day-of-the-week effects. Implications of these findings for the study of aggression are discussed.

Folk wisdom suggests that uncomfortably hot environments promote increased interpersonal aggression. This lay theory has won fairly general acceptance, as reflected by the report from the U.S. Riot Commission (1968) and by the fire- and heat-related imagery that pervades descriptions of anger and aggression (e.g., "tempers flaring," "being hot under the collar," "doing a slow burn"). Laboratory research has, indeed, shown that uncomfortably warm temperatures consistently produce a wide variety of negative affects, including dislike of other people (e.g., Griffitt, 1970; Griffitt & Veitch, 1971).

Laboratory research on the effects of ambient temperature on aggression has yielded somewhat more complex results. Under some conditions higher temperatures have led to increased aggression; under other conditions higher temperatures have led to decreased aggression (Baron, 1972; Baron & Bell, 1975, 1976; Baron & Lawton, 1972; Bell & Baron, 1976).

The prevailing model of aggression incorporating these various findings asserts that aggression is curvilinearly related to negative affect (Baron, 1979). As negative affect increases so does aggressive behavior, up to a critical inflection point. Beyond this point, further increases in negative affect decrease aggression. Because hot temperatures increase negative affect, the model predicts that hot temperatures will sometimes increase and sometimes decrease aggression, depending on which side of the inflection point the total negative affect happens to fall. The inflection point, basically, is the point at which the relative strength of the two predominant behavior tendencies—aggressing versus escaping from the situation—are approximately equivalent. When aggression is predominant, increased temperature leads to increased aggression; when escape is predominant, increased temperature leads to increased escape (and decreased aggression).

A most elegant demonstration of the predicted curvilinear relationship between negative affect and aggression has been provided by Bell and Baron (1976).[1] In that study, eight levels of negative affect were induced by factorially combining three variables. Subjects received a positive or a negative evaluation from a high- or a low-similarity confederate under cool or hot temperatures. Subsequent aggression by the subject toward the confederate was, as predicted, curvilinearly related to the induced level of negative affect.

Although our major interest here is in the temperature–aggression relationship, it is interesting to note that other manipulations of

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[1] We have not been able to locate any laboratory studies demonstrating a curvilinear relationship between temperature and aggression.

negative affect have yielded similar results. For example, Rotton, Frey, Barry, Milligan, and Fitzpatrick (1979) showed that aggression (in a laboratory setting) was higher when subjects were exposed to a moderately noxious odor than when exposed to either an extremely noxious odor or when in a normal (no-odor) environment. Also, Matthews, Paulus, and Baron (1979) demonstrated an interactive effect of crowding on aggression similar to the earlier cited temperature interactive effects.

A major impetus to the laboratory studies of the temperature–aggression relationship was the lay observation that aggression seems to increase as temperature increases in the real world. Indeed, most of the articles reporting on these laboratory studies have explicitly discussed the relevance of their findings to understanding aggression in the streets. But there are surprisingly few field studies on this topic, despite the advantages such studies would provide as converging evidence. Concerning external validity, there are two major differences between the laboratory studies of temperature effects and any field study. In the laboratory studies the hot temperatures are a salient part of the laboratory manipulations, and the subjects know that they can escape the aversive temperature when the lab session is over. Ambient temperature in the field, however, is neither as salient a causal factor nor is it as escapable. These differences may change the observed temperature–aggression relationship, depending on what produces the curvilinear relationship in the lab.

There appear to be two plausible alternative explanations for this inverted-U relationship that differ from Bell and Baron's competing behavioral tendencies explanation. The first suggests that temperature manipulations in the laboratory, especially the large ones used in these studies, are quite obvious to subjects. Indeed, Bell and Baron (1976) felt compelled to tell their subjects that temperature effects were being examined. As noted earlier, a common lay theory in our culture is that high temperatures increase aggressive tendencies. Thus, it is quite possible that some subjects may guess that the experimenter is trying to see if hot temperatures produce high aggression levels. This guess would most likely occur in the hot-temperature conditions, because the hot temperature is a salient, unusual condition. In addition, this guess would most likely occur in high-negative-arousal conditions because these, too, are unusual (i.e., very negative evaluations) and because the subject's behavioral inclination (aggression) may be unusual and salient. In sum, a subject's correct guess about the experiment's intent would most likely occur in the hot, negative-arousal conditions. If subjects attempt to show their independence or to sabotage the experiment by behaving opposite to what they think the experimenter wants, as suggested by recent research (Berkowitz & Donnerstein, 1982; Kruglanski, 1975; Turner & Simons, 1974), the curvilinear effect observed in laboratory studies could simply be an experimental artifact. (Note that this alternative does not seem as applicable to the noxious odor and crowding manipulations discussed earlier, because there do not appear to be general cultural beliefs relating these variables to aggression.)

A field study would not be subject to this artifact because the subjects would be unaware of their participation. Thus, finding an inverted-U relationship between temperature and aggression in such a setting would rule out this interpretation and greatly strengthen the Bell and Baron model.

The second alternative suggests that the aggression levels are mediated by subjects' attributions for their own negative arousal and for the confederate's behavior. For instance, in the high-negative-arousal conditions (e.g., negative evaluation, hot temperature, dissimilar confederate) subjects may overattribute their arousal to the high temperature because it is such a salient factor in that situation. On the other hand, the confederate's negative evaluation may be attributed to the heat. In either case, less aggression would result than in the corresponding cool-temperature condition, where the negative arousal is more completely attributed to anger. This seems likely because the high temperature in the lab is very salient (see Taylor & Fiske, 1978) and the high negative affect creates an explanation-provoking situation (see Anderson, 1983; Heider, 1958; Kelley, 1967, 1973; Pyszczynski & Greenberg, 1981; Wong & Weiner, 1981). On the other side of the inflection point (positive evaluation, similar confederate) little aggression results under cool temperatures because there is little or no negative arousal. Hot temperatures, though, would create some negative arousal that may be partially misattributed to anger at the confederate, resulting in relatively more aggression.

Whereas the explanation of competing behavioral tendencies predicts the same curvilinear effects for the lab and the field, the attribution prediction is a bit more complex. A large number of attribution researchers have demonstrated that people often underestimate the effects of situational factors (cf. Ross, 1977; Ross & Anderson, 1982). Such may be the usual case for temperature, particularly in field settings, where it is seen as a background factor. It may be that anger arousal is overattributed to temperature only in unusual settings that make temperature particularly salient, as in the high-negative-arousal conditions in the laboratory studies. Thus, by underestimating temperature effects in field settings, people may behave more aggressively as temperature (and frustration, annoyance, and negative affect) increases. Field studies that yield a linear (or monotonic) temperature–aggression relationship and not the laboratory inverted-U would be consistent with this attribution model. It should also be noted that an inverted-U relationship in a field setting could be predicted by the attribution model, but only if the effects of temperature on negative affect were overestimated (and overcompensated) by the population being studied. Given people's tendency to underestimate situational factors, this possibility seems remote. Furthermore, selection of target behaviors (as aggression measures) that are unusually aggressive would seem to insure that overestimation of temperature effects could not occur.

In sum, field studies would seem to provide good tests of the hypothesized inverted-U relationship between temperature and aggression because of their high external validity and because temperature is relatively less salient as a potential cause of aggressive impulses in such settings.

A literature review turned up only one published data set examining the temperature–aggression relationship in a naturalistic setting. Carlsmith and Anderson (1979; in a reanalysis of data originally collected by Baron and Ransberger, 1978) discovered that for riots in the years of 1967 to 1971, the conditional probability of a riot (conditional on temperature) increased as a monotonic function of the ambient temperature. There was no evidence of the laboratory-predicted curvilinear downturn at high temperatures.

Although these results directly contradict the Bell and Baron curvilinear model, the limitations of that data set should not be ignored. As Carlsmith and Anderson pointed out, neither riots in different locations nor temperatures on different (but close) days are independent. The actual number of truly independent data points is therefore unknown. In addition, there were so few days falling within the higher temperature intervals that the estimated conditional probabilities were likely to be somewhat unstable.

The two studies to be reported in this article further examine the temperature–aggression relationship in field settings using measures of aggression that reduce the problems encountered in the riot study. Both studies use criminal assaults as the dependent measure of aggression and daily temperature as the independent variable. The number of assaults on one day are probably fairly independent of the number on other days. In addition, by gathering these data over a large number of days we get fairly stable estimates of aggression at all normal temperatures, including those that are fairly hot. Application of standard regression analyses to these data will allow tests of the linear relationship and the quadratic (curvilinear) relationship of temperature and aggression.

Study 1

The data to be examined in Study 1 were originally collected by Jones, Terris, and Christensen (1979).[2] The description of the data collection procedures is based on their manuscript and a personal communication from Jones (July 1979). Our data analyses are entirely different from theirs, and we feel they also yield tests that are more appropriate for the main questions of interest.

[2] We would like to thank John Jones for providing these data to J. Merrill Carlsmith and the senior author. Note that the average temperature of one data point was missing (out of 91), necessitating deletion from the analyses to be reported.

Method

The number of individual criminal assaults reported on each of 90 days in June, July, and August of 1977 in Chicago were used as the main dependent variable. The assaults tallied on each day included homicide, rape, battery, and armed robbery. These data were obtained from confidential files of the main police precinct in metropolitan Chicago. The average temperature on each day was calculated from 24 hourly readings reported by the National Weather Service's *1977 Local Climatological Data: Chicago Edition.*

We added another predictor variable, day of the week, to allow more precise tests of the main hypotheses by removing variance associated with day of the week.

Results and Discussion

Regression analyses were performed on these data with number of assaults as the criterion variable and day of week, temperature, and temperature squared as the predictors. (The temperature squared term was used to test the curvilinear hypothesis; see Cohen & Cohen, 1975.)

As expected, day of the week accounted for a significant portion of the variance in assaults, $F(6, 82) = 4.78$, $p < .001$. Briefly, Saturdays, Sundays, and Mondays had the highest rates of reported assaults.

As predicted, temperature was linearly related to assaults, $F(1, 82) = 8.80$, $p < .005$. Number of assaults increased as temperature increased. There was no evidence of a curvilinear trend ($F < 1$).

One might postulate that the predicted downturn in aggression would occur only if high temperatures prevailed for several days.[3] That is, the average temperature of the preceding days may add some predictive power to the model. We tested the effects of the average temperature of the preceding 3 days and the preceding 5 days on daily assaults. There were no significant linear or curvilinear effects for the averages (Fs < 1).

This data set thus replicates the findings of Carlsmith and Anderson (1979) using a very different measure of aggression, and contradicts the Bell and Baron curvilinear model.[4] One could argue, of course, that there are still too few hot days to reliably produce the decrease in aggression observed in the lab studies. In addition, the inclusion of robbery in the assault measure may be faulted, because robbery may be less an anger or frustration response than a way of making a living. To address these issues a more extended replication study was conducted in which crimes were broken down into aggression–anger crimes (rape and murder) and nonaggression–nonanger (at least, less spontaneously aggressive) crimes (robbery and arson). These data were collected over a 2-year period in Houston, Texas, which yielded plenty of hot-day data for a curvilinear effect to make its appearance.

Study 2

Method

The number of aggressive (murder and rape) and nonaggressive (robbery and arson) crimes were recorded from the *Houston Chronicle* newspaper crime report for each day that these crimes were reported.[5] These figures were based on crime statistics reported to the *Chronicle* by the Houston police. Note that these figures were not reported in the *Chronicle* every day.

The maximum ambient temperature for each day was recorded from reports of the National Oceanic and Atmospheric Administration (1980–1982).[6] These data were collected for the period of October 12, 1980 through September, 1982. For aggressive crimes complete data were available for 311 days; for nonaggressive crimes complete data were available for 215 days. For both types of crimes, complete data were available for 214 days.[7]

We also recorded day of the week, month, and year as additional predictor variables so that variance associated with these variables could be removed. Month and year did not have meaningful or systematic effects; they will not be considered further.

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[3] We thank Robert A. Baron for suggesting this possibility.

[4] Jones, Terris, and Christensen (1979) originally reported a marginally significant curvilinear effect of temperature in these data. An inspection of these data, their analyses, and the present regression analyses reveals that their analysis of variance approach and the grouping of data required by it capitalized on random fluctuations of the assaults and on the day-of-the-week effects.

[5] Our original intent was to gather crime data from the police department. However, we were unable to get the cooperation of the Houston, Dallas, or South Bend, Indiana, police departments.

[6] Note that the results of this study do not change in any substantial way if average or minimum temperature is used instead of maximum temperature.

[7] We noticed on several occasions that the crime statistics on consecutive days were identical. Because the *Houston Chronicle* frequently publishes the same news item on several days, we inferred that the identical crime statistics were also a mistake. Therefore, when this occurred we included the crime data only for the first day it was reported.

Results and Discussion

Regression analyses were performed on these data with aggressive (murder and rape) and nonaggressive (robbery and arson) crimes as criterion variables and day of the week, temperature, and temperature squared as predictor variables.

Aggressive crimes were significantly associated with day of the week, $F(6, 303) = 44.27$, $p < .0001$. The high-crime days on this measure were Sunday and Monday. This result is very similar to that obtained with the Chicago data.

There was also a significant linear relationship between temperature and aggressive crime, $F(1, 303) = 8.02$, $p < .005$. As with the Chicago data, aggressive crime increased in frequency as temperature increased. Also similar to the Chicago data was the finding of no curvilinear relationship between temperature and aggressive crime ($F < 1$). Figure 1 presents these data, combined by temperature, into five groups of approximately equal size (*ns* ranged from 61 to 63).

If temperature is indeed a causal agent in aggression, we should expect not only a significant relationship between temperature and aggressive crime, but also a weaker relationship (or none) with less aggressive crime. The nonaggressive crimes in the present data set were unrelated to temperature, temperature squared, and day of week (all $Fs < 1$).

To further test this hypothesis, we calculated an aggressive crime ratio by dividing the number of aggressive crimes on each day by the corresponding number of nonaggressive crimes. On this index, then, a high score indicates that a relatively high proportion of the crimes committed on that day were aggressive. Thus, if temperature selectively affects aggressive crimes, we expect temperature to be positively related to this index. Regression analyses confirmed this prediction. Day of the week again accounted for a significant portion of the variance, $F(6, 206) = 6.92$, $p < .0001$. More interestingly, there was a linear effect of temperature, $F(1, 206) = 7.33$, $p < .008$. Finally, there was a marginally reliable curvilinear effect, $F(1, 205) = 4.14$, $p < .05$. This effect was opposite in form to that predicted by the negative affect model, as can be seen in Figure 2. (Again, the data were combined by temperature into five groups of approximately equal size; sample sizes ranged from 41 to 45.) We caution against overinterpretation of the curvilinear effect because it is so weak.

In sum, on both the aggressive crime and the ratio measures, the predicted positive linear relationship with temperature was obtained. The downturn in aggressive crime at high temperatures predicted by the negative affect model did not occur on either measure.

General Discussion

The consistency of results across the major field studies in this area is impressive. The Carlsmith and Anderson (1979) riot data and

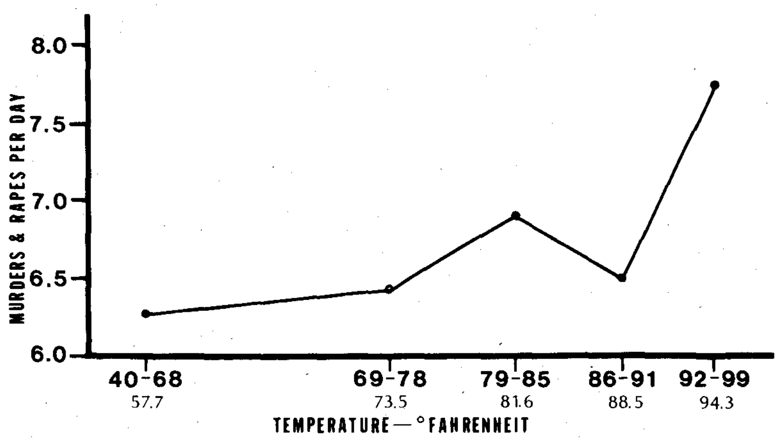

Figure 1. Aggressive crime (murder and rape) as a function of maximum ambient temperature. (Note that along the abscissa points are plotted at the category-weighted average temperature, as indicated by the small-sized digits. The larger digits indicate the range of temperatures included in each category. The categories were constructed to represent approximately equal numbers of days.)

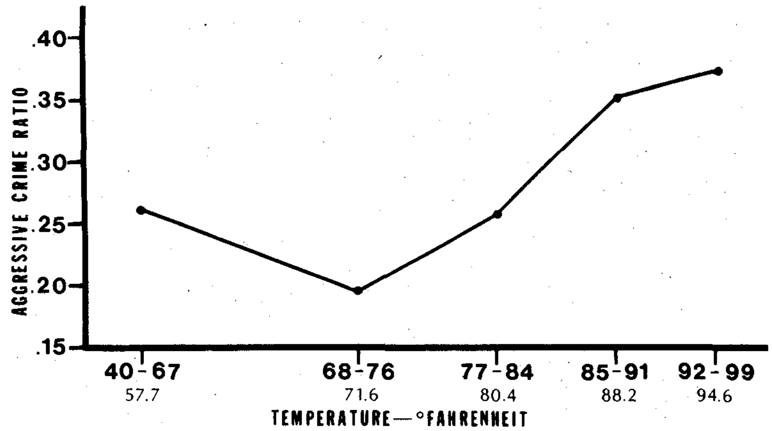

Figure 2. Aggressive crime ratio (number of murders and rapes divided by the number of robberies and arsons) as a function of maximum ambient temperatures. (Note that along the abscissa points are plotted at the category-weighted average temperature, as indicated by the small-sized digits. The larger digits indicate the range of temperatures included in each category. The categories were constructed to represent approximately equal numbers of days.)

the present two studies on crime suggest that aggression is linearly (or monotonically) related to ambient temperature across different dependent variables and across different U.S. cities. In addition, a recent unpublished article by Cotton (1982) reported a significant linear correlation between temperature and violent crime, and no curvilinear effect, for a large midwestern city. However, as Carlsmith and Anderson (1979) pointed out, the relationship must become curvilinear at some point, because at extremely high temperatures everyone gets sick and dies, precluding aggressive acts. The question is whether the decrease in aggression with increasing temperatures occurs within the normal range of temperatures. The field studies suggest that it does not.

Although these results do not conclusively rule out the Bell and Baron curvilinear negative affect model, they certainly require a reexamination of that model. The laboratory curvilinear effects could result from attributional processes or from the "sabotaging subject," as discussed earlier; both positions are consistent with the lack of curvilinear effects in field settings. As pointed out earlier, though, the noxious odors and crowding studies of negative affect and aggression make the sabotage alternative less plausible, suggesting that the attribution model might be the most fruitful one to examine in future studies.

One could defend the original curvilinear model by suggesting that in the field studies, the inflection point (the point at which increases in negative affect leads to decreases in aggression) is not reached. This seems unlikely for at least two reasons. First, the aggressive acts used as dependent variables (riots, murders, rapes) certainly imply very high levels of negative affect. Second, the types of conditions that Baron and his colleagues have suggested should contribute to general negative affect in city environments are present in the environments of the field studies (cf. Baron, 1979; Bell & Baron, 1976). Houston, for instance, is noted for its congested traffic, high temperatures, high humidity, noise, and air pollution, all of which should push the populace past the negative affect inflection point during the hot summer months.

Finally, we would like to acknowledge that the field studies discussed in this article all are based on correlational data. Thus, causal inferences should be made with great caution and in conjunction with other theoretical and empirical sources of evidence. We do not believe, nor do we wish to imply, that our data conclusively prove that the temperature–aggression relationship is linear. There are likely several mediating variables that interact in as yet unknown ways. The relative over- and underestimation (or attribution) of temperature effects may be one such variable. We feel that a better understanding of aggression in general—and temperature–aggression relationships in particular—can be reached only by judicious use of more field studies and laboratory experiments. At this point, it seems critical that the curvilinear relationship found in the laboratory be reexamined for these potential mediators.

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