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Is the Curve Relating Temperature to Aggression Linear or Curvilinear? Assaults and Temperature in Minneapolis Reexamined

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Using archival data from Minneapolis recorded in 3-hr time intervals, E. G. Cohn and J. Rotton (1997) concluded that there is an inverted U-shaped relationship between temperature and assault, with the maximum assault rate occurring at 74.9 °F. They depicted this relationship by plotting temperature against assault. This plot, however, fails to take into account time of day. Time of day was strongly related to both temperature and assault, but in opposite directions. Between 9:00 p.m. and 2:59 a.m. of the next day, when most assaults occurred, there was a positive linear relationship between temperature and assault. The Minneapolis data actually provide stronger support of a positive linear (or monotonic) relationship between temperature and assault than of an inverted U-shaped relationship.

Keywords: aggression, assault, heat, hot, temperature

Empirical studies of the relationship between temperature and aggression date back to the late 1800s (Anderson, 1989). One common belief displayed by philosophers, literary writers, and laypeople alike is that hot temperatures increase aggression and violence. This belief has even crept into the English language, as indicated by such common phrases as "hot headed," "hot tempered," "hot under the collar," and "my blood is boiling."

Overall, the evidence from laboratory experiments, field experiments, correlational studies, and archival studies of violent crimes indicates that hotter temperatures are associated with higher levels of aggression (for comprehensive reviews, see Anderson, 1989, 2001; Anderson & Anderson, 1998; Anderson, Anderson, Dorr, DeNeve, & Flanagan, 2000). Studies that compare the violence rates of regions that differ in climate have generally found that hotter regions have higher violent crime rates (e.g., Anderson & Anderson, 1996; Lombroso, 1899/1911). Time period studies generally have found relatively higher violence rates in hot years, seasons, months, and days (e.g., Anderson, Bushman, & Groom, 1997; Leffingwell, 1892). Field and archival studies find similar results. For example, there is a positive relation between temperature and number of major league batters hit by pitched balls (Reifman, Larrick, & Fein, 1991).

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Theoretical Explanations of the Curve Relating Temperature to Aggression

Berkowitz (1983) proposed that aversive events produce negative affect and that negative affect, in turn, increases aggression. Aversive events can be either nonsocial (e.g., extreme temperatures, physical pain, loud noises, unpleasant odors, and smoke) or social (e.g., interpersonal frustration and provocation). Previous research has shown that as temperatures rise to uncomfortable levels, so does negative affect (Anderson, Anderson, & Deuser, 1996; Anderson, Deuser, & DeNeve, 1995). According to negative affect theory, increases in heat-induced negative affect are associated with a building of aggressive motives that increases the likelihood that an individual will behave aggressively (Anderson, 1989).

An alternative theoretical explanation is that hotter temperatures may decrease aggression under some circumstances. Baron (1972) first proposed this when some of his hot experimental conditions resulted in either no increase or an actual decrease in aggression (see also Baron & Bell, 1975, 1976). This theory, dubbed "negative affect escape" theory by Anderson (1989), posits that high levels of negative affect induced by hot temperatures should lead to stronger escape motives than to aggressive motives, resulting in an inverted U-shaped relationship between temperature (ranging from comfortable to hot) and aggression.

Baron and Ransberger (1978) reported data they believed were consistent with an inverted U-shaped relationship between temperature and the occurrence of riots in the United States. Unfortunately, they did not take into account the underlying distribution of daily temperatures, which in major U.S. cities includes many more days with maximum temperatures of 70–80 °F than days with maximum temperatures of 90–100 °F. When the temperature distribution is taken into account, the inverted U function disappeared and became a monotonically increasing function (Carlsmith & Anderson, 1979).

Although nonexperimental studies are sometimes used to test theories of heat-related aggression, experimental studies provide cleaner tests. A meta-analysis of experimental studies found no support for an inverted U-shaped relationship between temperature and aggression (Anderson et al., 2000). The best evidence to date that under some conditions "normal" hot temperatures (e.g., under 100 °F) can cause a decrease in aggression comes from one experiment by Anderson et al. (2000), but it occurred only under fairly restrictive conditions (e.g., ambiguous provocation, later aggression trials).

Cohn and Rotton (1997) reported archival data they believed were consistent with negative affect escape theory (see also Rotton & Cohn, 2000). Using archival data on assault rates in Minneapolis, Minnesota, they concluded, "as predicted by the negative affect escape model, assaults declined after reaching a peak at moderately high temperatures" (Cohn & Rotton, 1997, p. 1322). In this article, we reanalyze Cohn and Rotton's data set from Minneapolis.

Cohn and Rotton's (1997) Study

Cohn and Rotton (1997) conducted an archival study of temperature and assault rates in Minneapolis between 1987 and 1988. Both temperature and assault rates were recorded at 3-hr daily intervals. To depict "assault as a function of temperature" (Cohn & Rotton, 1997, p. 1325), Cohn and Rotton plotted mean assaults and mean temperatures for 12 temperature intervals. They found that "assaults declined after reaching a maximum of 74.9 °F" (p. 1324). This relationship is shown in Figure 1 with standard error bars (see also Figure 1 in Cohn & Rotton, 1997, p. 1325).

The curve depicted in Figure 1 can show only the marginal relationship between temperature and assault. However, the observed relationship between two variables can change radically when one takes into account the other lurking variables that lie hidden in the situation. This problem is called the Simpson paradox (Moore, 2000, pp. 147–149). In the present situation, one

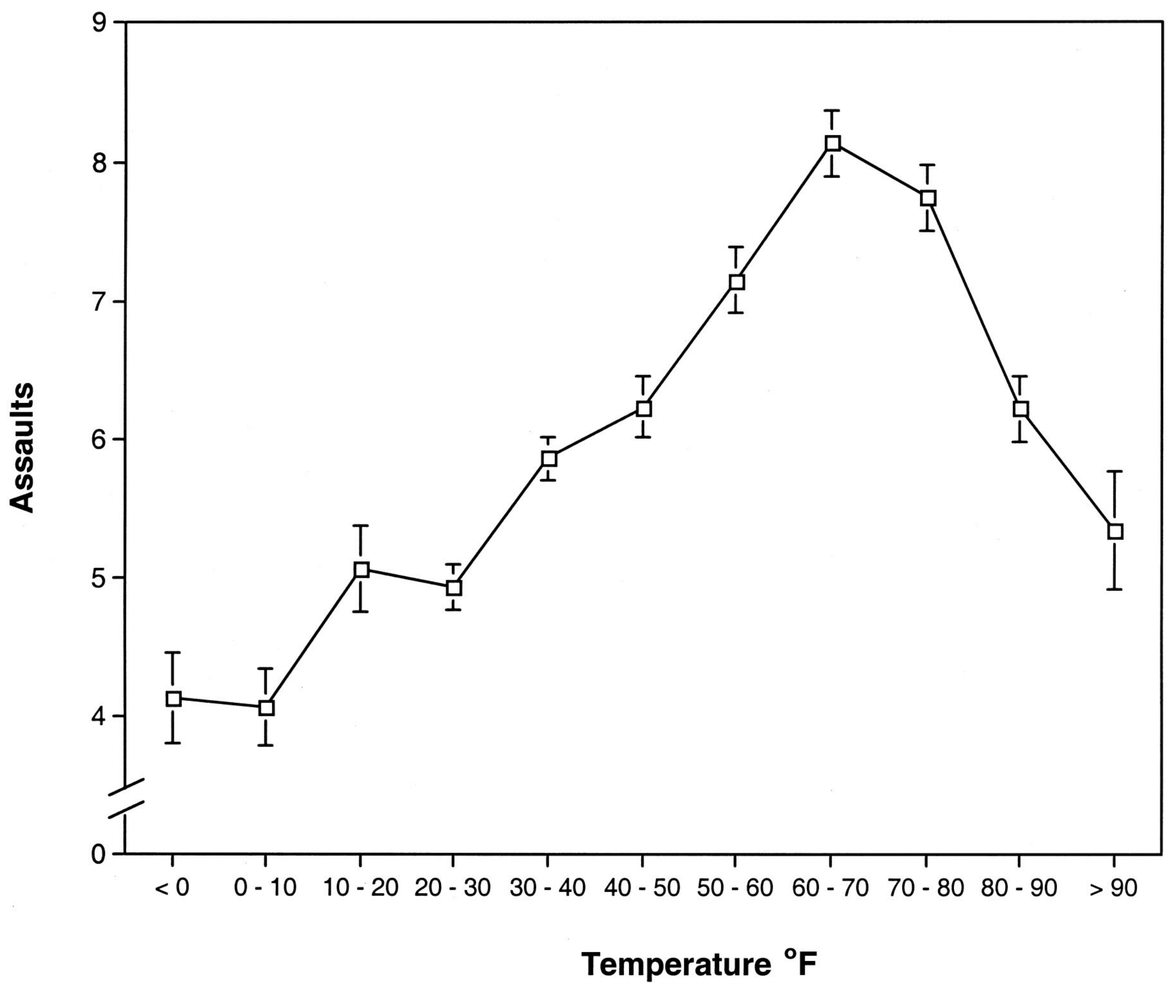

Figure 1. Relationship between temperature and assault, ignoring time of day. Error bars represent plus or minus one standard error.

lurking variable is time of day. As can be seen in Figure 2, both assault and temperature are strongly related to time of day, but in opposite directions. Assaults are highest between 9:00 p.m. and 2:59 a.m. of the next day, when most people engage in discretionary activities. In contrast, temperatures are highest between 9:00 a.m. and 5:59 p.m., when most people engage in obligatory activities (e.g., working, attending school). Thus ignoring time of day within an analysis produces a misleading picture of the relationship between temperature and assault.

To understand the relationship between temperature and assault, one must take into account time of day. Figure 3 shows the relationship between temperature and assault for high (9:00 p.m. to 2:59 a.m.) and low (3:00 a.m. to 8:59 p.m.) assault time periods. Note that there is a positive linear relationship between temperature and assault between 9:00 p.m. and 2:59 a.m., the time of day when most people are involved in discretionary activities.

Cohn and Rotton (1997) did include time of day in Tables 4 and 5 of their article. However, these data are also inconsistent with the claim that there is an inverted U-shaped relationship between temperature and assault. In Table 4, only 2 of the 8 quadratic coefficients reported were statistically significant, and 1 of the 2 was positive (indicating an upturn in assaults at high temperatures rather than a downturn). In Table 5, only 10 of the 56 quadratic coefficients reported were significant, and 7 of the 10 were positive. There is also a common misunderstanding about how to interpret a quadratic effect in the presence of a linear effect. The existence of a significant negative quadratic effect does not necessarily indicate that an inverted U-shaped relationship exists. If there is a positive linear slope, for instance, a negatively sloped quadratic effect may merely indicate an asymptote (i.e., the curve levels off because the linear effect is smaller at higher temperatures than at lower temperatures).

Another problem with Cohn and Rotton's (1997) statistical analyses is that they controlled for month of year. Because month is so highly related to temperature in Minneapolis, partialing out month effects artificially reduces linear temperature effects and thereby changes the resulting temperature–aggression function (Anderson et al., 2000).

It is also difficult to test the hypothesis that assaults decrease when temperatures are very hot by using data from Minneapolis,

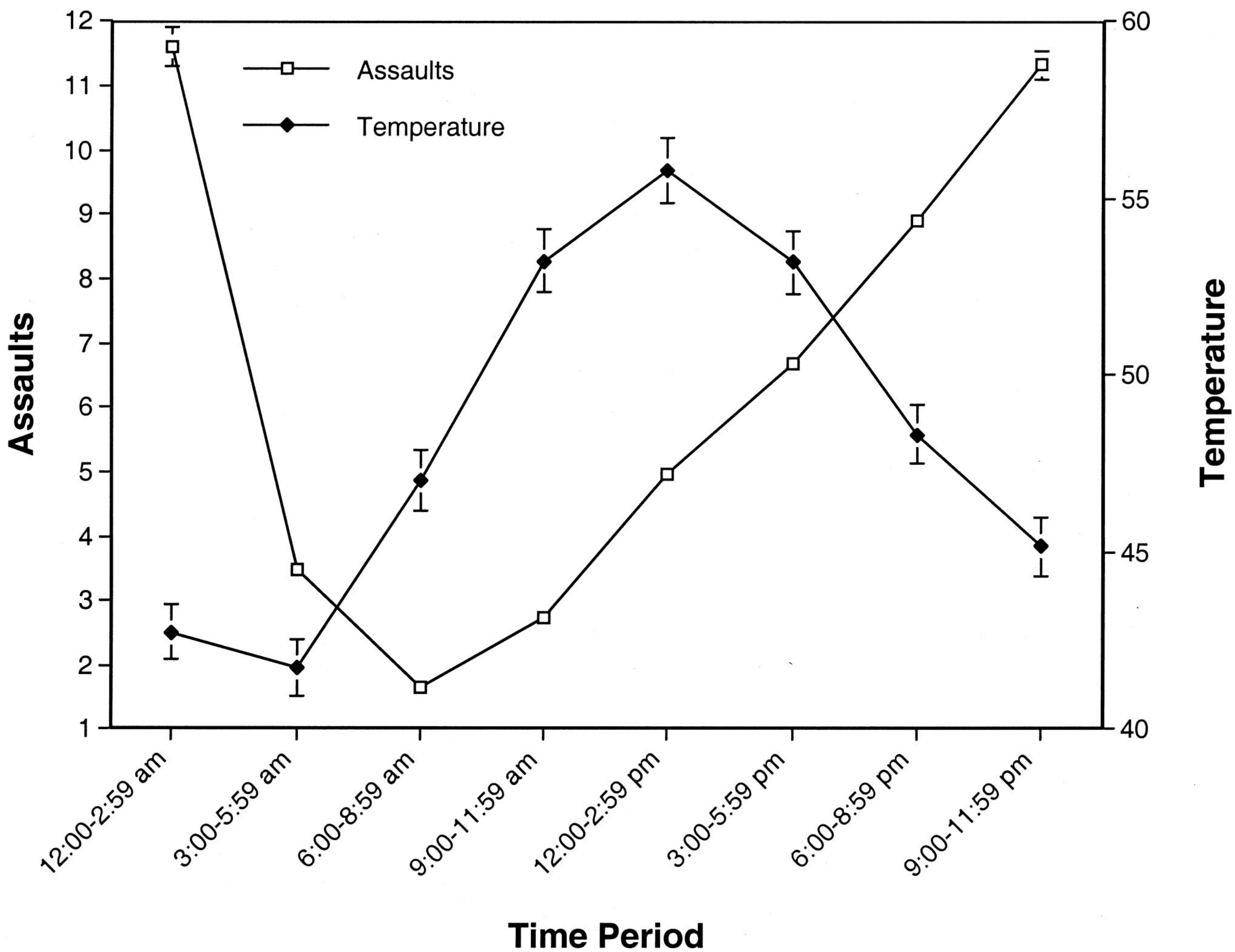

Figure 2. Relationship between mean temperature, time of day, and mean assaults. Error bars represent plus or minus one standard error.

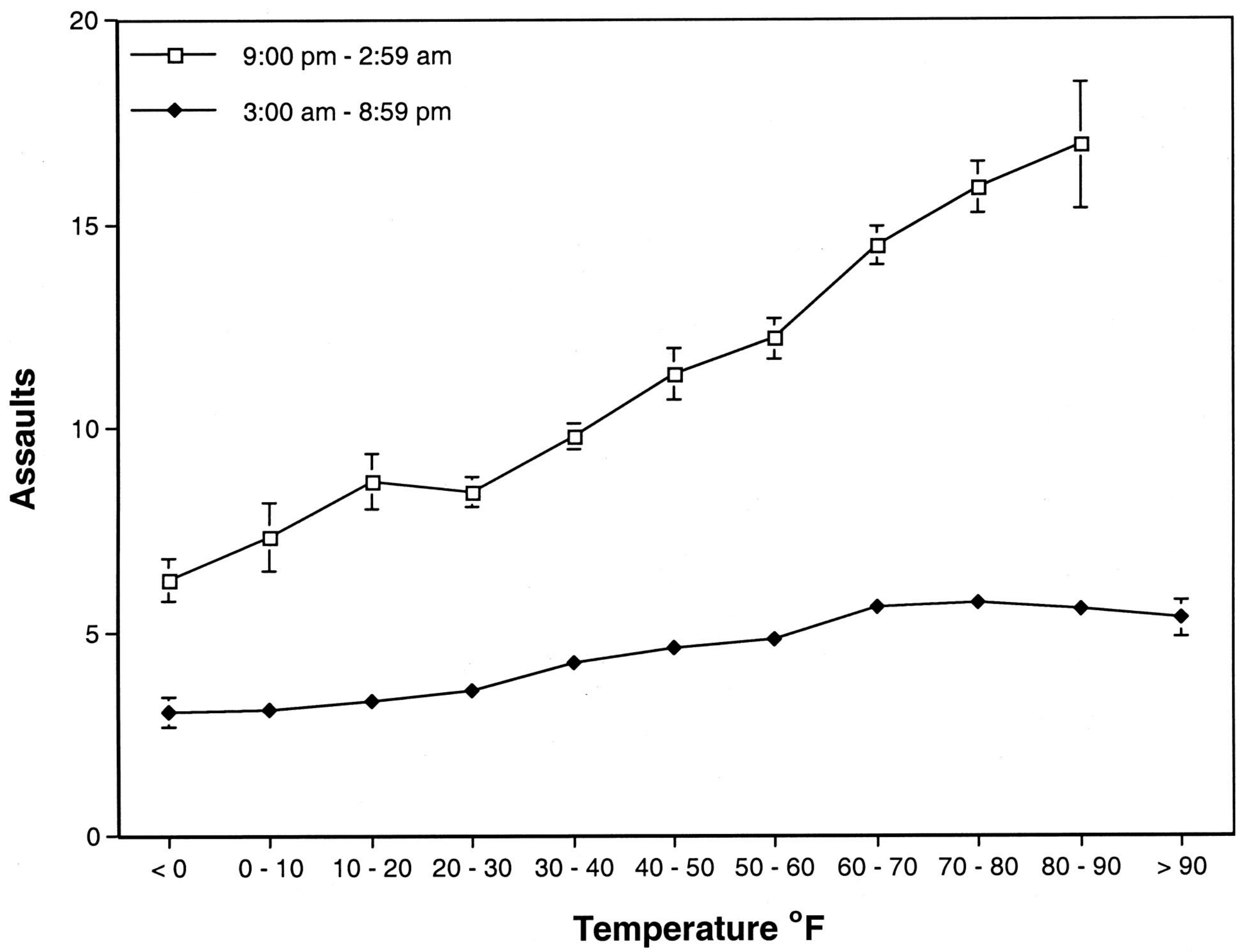

Figure 3. Relationship between temperature and mean assault during high (9:00 p.m. to 2:59 a.m.) and low (3:00 a.m. to 8:59 p.m.) assault periods.

Minnesota. Of the 568 observations greater than 79 °F (see Table 3 in Cohn & Rotton, 1997, p. 1327), only 24 observations occurred between 9:00 p.m. and 2:59 a.m. (the time when assaults are highest).

More recently, Rotton and Cohn (2000) used a more appropriate city for analysis—Dallas, Texas. As in Minneapolis, the temperature and assault rates in Dallas were recorded at 3-hr daily intervals. The authors stated that the Dallas results replicated the Minneapolis results, showing that "assaults were an inverted U-shaped function of temperature" (p. 1074). To depict this function, Rotton and Cohn plotted mean assaults and mean temperatures for nine temperature intervals (see Rotton & Cohn, 2000, Figure 1, p. 1077). Unfortunately, Figure 1 in Rotton and Cohn's article also fails to take into account the time of day in which assaults and temperatures were recorded. Figure 2 of their article (Rotton & Cohn, 2000, p. 1078) shows the same linear pattern depicted in Figure 3 of our article. During high assault periods, there is a strong positive linear relationship between temperature and assault. Thus, the Dallas data also provide stronger support of a positive linear relationship between temperature and assault than of an inverted U-shaped relationship.

Discussion

In short, Cohn and Rotton's (1997) claim that assault rates decrease as temperatures reach uncomfortably hot levels is a classic example of the Simpson paradox. Time of day is one important variable related to both temperature and assault, but in opposite directions. When one plots the relationship between temperature and assault separately for different time periods, there is no downturn in assault at the hottest temperatures (i.e., 70–90 °F). A downturn in assault may occur at temperatures greater than 90 °F during these time periods, but one cannot detect it because of a lack of data in this temperature range in the Minneapolis data set. In the Dallas data set, no downturn in assaults is apparent for temperatures greater than 90 °F during nighttime hours (see Figure 2 in Rotton & Cohn, 2000, p. 1078). Meta-analysis of experimental studies also fails to find support for the negative affect escape model prediction of decrease in aggression at hot temperatures when there are additional negative-affect-inducing contextual variables (Anderson et al., 2000). Thus, the available evidence provides stronger support for negative affect theory (Berkowitz, 1983) than for negative affect escape theory (Anderson, 1989). We believe that there are circumstances in which hot temperatures (compared with comfortable ones) can yield decreases in aggression, but those circumstances appear to be quite limited in scope, based on processes not included in the negative affect escape model, and, to date, undiscovered in naturalistic settings (e.g., Anderson et al., 2000).

Despite our misgivings about the original analyses presented by Cohn and Rotton (1997), there are at least four positive lessons that can be gleaned from this and related work. First, the use of data with a shorter time span during which both temperature and aggression are assessed emphasizes the difficulty of interpreting archival data. In general, it would seem that the closer in time that the target aggressive behaviors and corresponding temperatures are assessed, the purer the assessment of the true temperature–aggression relationship would be. In field settings, however, there are other major aggression-inhibiting and aggression-facilitating factors at work, factors that often are correlated highly with temperature. For example, there are strong inhibitions against committing aggressive acts at work, church, or school, even if heat-induced negative affect is most likely to occur during these times of day. In addition, humans can easily carry their anger and aggressive intentions forward in time, such as through rumination (Bushman, Bonacci, Pedersen, Vasquez, & Miller, 2005). If archival data are used to test theories of temperature-related aggression, it is important to control for dynamic interpersonal processes and routine activities that are related to time of day and day of week. If these dynamic processes are not controlled, the optimal unit of analysis may be relatively longer time spans (e.g., days instead of hours). Second, the best method to test the underlying processes of heat-related aggression is experimental. Third, from the purely practical standpoint of staffing police departments and emergency rooms for optimal ability to react to extreme acts of aggression, the best data are actuarial and do not depend on underlying theory. Fourth, from an intervention perspective, one needs to know both the actuarial statistics and the theoretical underpinnings. On the basis of data and theory, interventions could be designed to help people identify and reduce environmental stressors in their lives (e.g., hot temperatures, loud noises, and crowded conditions). Reductions in environmental stress would be expected to yield reductions in social conflict within interpersonal and intergroup relationships.

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