WEATHER, DISORDERLY CONDUCT, AND ASSAULTS
From Social Contact to Social Avoidance

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ABSTRACT: It is proposed that the seemingly contradictory predictions of routine activity theory and the negative affect escape (NAE) model of aggression can be reconciled by viewing inclement weather (particularly extreme heat and cold) as a factor that reduces social contact by leading individuals to avoid outdoor settings. This proposal was evaluated by combining previously published data on assaults with unpublished data on complaints about disorderly conduct, which reflect the less savory aspects of social contact. Moderator-variable time-series analyses of data from Minneapolis, Minnesota, covering a 2-year period, indicated that the inverted U-shaped relationship between temperature and assault was reduced, and temperature’s interaction with seasons vanished, following statistical control for complaints about disorderly conduct.

There is an old saying: “If you can’t stand the heat, stay out of the kitchen.” This saying, which is usually credited to Harry S. Truman, highlights a connection that is assumed to exist between high temperatures and hostility.

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(Anderson & Anderson, 1998; Cohn, 1990a; Parker, 1995). It also suggests a strategy for coping with both: avoid hot places and people who get “hot under the collar.” Avoidance can be regarded as the opposite of social contact, which is frequently invoked to explain seasonal differences in criminal behavior. According to the social contact hypothesis, crime occurs when pleasant weather brings people together: “The greater frequency of crimes against the person in summer months is probably due to the greater frequency of contact among human beings in those months rather than the effects of temperature on the propensity to criminality” (Sutherland & Cressey, 1978, p. 119).

Although the social contact hypothesis is frequently advanced as an explanation for relations between temperature and criminal behavior (Dodge & Lentzner, 1980; U. S. Department of Justice, 1988), we believe that it presents a somewhat misanthropic view of human interaction. Obviously, social contact does not always lead to crime and violence. M. Felson (1998) has pointed out that although violence is more likely to occur when young people come into contact in a barroom setting, violent encounters rarely occur when groups are composed of persons of mixed ages and both sexes (e.g., families, church socials, the workplace). There are exceptions, of course, such as domestic violence (Cohn, 1993; Rotton & Frey, 1985); however, if everything else is equal, contact appears to be a necessary, but not a sufficient, condition for violence and aggression. We believe that a stronger case can be made for the following proposition: Anything that keeps people apart will reduce violence and aggression. This proposition is so obvious that the first thing that third parties in disputes (i.e., guardians, such as the police) frequently do is to “separate the parties” (Sherman, 1992). Thus, instead of arguing that pleasant weather promotes social contact, it may be more useful to regard inclement weather (especially heat and cold) as a factor that reduces social contact by leading individuals to retreat to primary territories. This, in turn, reduces the probability of their coming into contact with strangers in public settings.

The distinction between contact and avoidance suggests a way to integrate predictions from the social contact hypothesis and the negative affect escape (NAE) model of aggression. According to Baron and Bell’s (1976) NAE model, moderate departures from comfortable temperatures facilitate aggression, but extreme temperatures provoke competing response tendencies, such as escape, that conflict with and thereby reduce aggression. The NAE model is based on experiments (e.g., Baron, 1978; Bell, 1992) in which participants came to a laboratory environment. As Asmus and Bell (1999) point out, participants in these experiments were not warned that they would be exposed to conditions that individuals normally avoid; thus, escape was
the only alternative to aggression. However, theories of punishment describe avoidance as well as escape as responses to aversive stimulation (Beck, 1983; Seligman, 1975). Not only do people try to escape aversive conditions, as psychological theories propose (Bell, 1992; Berkowitz, 1998), but they also engage in proactive behavior whose aim is to avoid conditions that might cause discomfort. For example, as several authors (e.g., Harries & Stadler, 1988) have suggested, individuals may choose to remain inside their air-conditioned homes on a hot day, thus reducing the possibility of social contact.

Our aim is to extend rather than replace or challenge the NAE model. Rather than focusing on how people behave on a hot day at the beach, it may be more useful to take cognizance of the fact that even the beaches in South Florida are deserted when the weather turns cold; and although we have not conducted a formal study, we have noticed that there are often fewer people at parks on hot afternoons. These informal observations are consistent with predictions that can be derived from routine activity (RA) theory (Cohen & Felson, 1979).

Stripped to its essentials, RA theory suggests that predatory crime occurs when events bring motivated offenders into contact with potential targets in the absence of capable guardians. This proposition is supported by a large body of research (Eck, 1995; Goldstein, 1994). Cohn (1990b) proposed weather conditions as a set of factors that brings offenders and victims into contact; for example, individuals are more likely to venture away from the safety and security of primary territories (homes and the work place) and enter public territories (e.g., convenience stores, bars, parking lots, and other “hot spots”) on warm days rather than cool or cold ones. Consistent with predictions that can be derived from RA theory, Cohn and Rotton (1997) found that relationships between temperature and assaults were stronger during evening than afternoon hours and on Fridays and Saturdays than other days of the week. These findings were based on 1987-1988 data from Minneapolis, Minnesota. They have since been replicated by results from an analysis of relations between temperature and assaults in Dallas, Texas (Rotton & Cohn, 2000).

Attempts to apply and extend RA theory to violent crimes (Landau & Fridman, 1993; LeBeau & Corcoran, 1990) have been hampered by the fact that the theory was originally developed to explain temporal variations in predatory crimes, such as burglary, larceny, and robbery (Cohn & Rotton, in press). Following the lead of social psychologists (e.g., Baron & Richardson, 1997), M. Felson (1998) has contrasted these goal-oriented activities (which are usually termed instrumental aggression) with expressive or affective aggression (e.g., fights). He pointed out that expressive aggression is more
likely to involve co-combatants (or co-offenders) than to have clearly defined perpetrators and victims. There are other theoretically interesting differences between expressive and instrumental aggression. For example, the third party in a violent confrontation (expressive aggression) may be an onlooker or friend of one of the combatants rather than a guardian, which may act to escalate rather than inhibit the crime (R. Felson & Steadman, 1983). Thus, although the distinction between offenders, guardians, and audience members is interesting from a theoretical standpoint, it introduces elements that may be impossible to quantify. In this report, we consider overall levels of interaction rather than contact between specific parties (i.e., between combatants, combatants and audience members, etc.).

OPERATIONALIZING SOCIAL CONTACT

Contrary to Occam’s razor, social contact and affect-based theories of violence introduce mediators that have yet to be measured and operationalized. For psychological theorists, the mediator has typically been negative affect, which can be measured in laboratory studies (e.g., Bell & Baron, 1976) but which has only been assumed to operate in a similar fashion in field (or real-world) settings. However plausible speculations about emotional states may be, investigators have not collected data that would allow them to show that relationships between temperature and aggregate levels of violence are, in fact, mediated by individual levels of negative affect. Similarly, those who favor social contact and RA theory have been derelict in finding out what people actually do at different temperatures. Excluding laboratory studies and except for a small number of field studies (Kenrick & MacFarlane, 1986; Reifman, Larrick, & Fein, 1991; Rotton, Shats, & Standers, 1990), our knowledge of temperature-aggression relationships is based almost entirely on analyses of police records. Those who favor RA theory frequently try to bolster their arguments by referring to results from time-budget studies (e.g., J. Robinson, Converse, & Szalai, 1972; J. Robinson & Godbey, 1997); unfortunately, such studies are silent about how atmospheric variables, including temperature, affect everyday behavior.

However, it is possible to extract a measure of social contact from police records; namely, disorderly conduct. The Federal Bureau of Investigation (1976, p. 81) defines disorderly conduct as “all charges of committing a breach of the peace.” The following were coded by police dispatchers in Minneapolis, Minnesota, as disorderly conduct (or more simply, disorders): disturbances, loud music, drunks, firecrackers, suspicious persons, suspicious
vehicles, unwanted persons, tenant trouble, neighbor trouble, customer trouble, kid trouble, hot rodders, and dogs barking. These activities correspond to what Taylor (1987) terms street hassles. They can also be described as incivilities (Skogan, 1990) that cause so much concern that they are reported to the police.

Disorders can be regarded as one of the less savory aspects of routine activities. Our definition of routine is somewhat broader than the one found in Cohen and Felson’s (1979) pioneering article. In our view, disorderly conduct is a by-product of activities (e.g., socializing, partying) in which individuals routinely engage during what J. Robinson and Godbey (1997) have labeled discretionary time. Disorders differ from violence (i.e., aggression in extra-laboratory settings), which is usually defined as “behavior directed toward the goal of harming or injuring another living being who is motivated to avoid such treatment” (Baron & Richardson, 1997, p. 7; cf. Archer, 1994). Although disorderly conduct is distinct from violence, there are two reasons to believe that it may be an antecedent or cause of violent behavior. First, as incivilities, disorders signal a tolerance for deviance (Wilson & Kelling, 1982). Second, as M. Felson (1998) has suggested, they describe conditions (e.g., loud partying, feuds over loud noise) that can often escalate into violent encounters.

MEDIATION, MODERATION, AND MEDIATED MODERATION

Merging the NAE model with theories that emphasize social contact, we hypothesize that disorderly conduct acts as an intervening variable that mediates relationships between temperature and assaults. This hypothesis is portrayed by the first (full mediation) diagram in Figure 1. As Evans and Lepore (1997) have discussed, there are three conditions that have to be met to establish mediation. First, temperature has to exert direct effects on assaults, as evidenced by regression analyses that uncover positive relationships between the presumed cause (temperature) and assumed effect (assaults). Second, as we have hypothesized, temperature should also be related to the presumed mediator (i.e., disorderly conduct). Finally, for a model of full mediation to receive support, the relationship between temperature and assaults should not attain significance in analyses that control for disorders. The first of these conditions was previously established by Cohn and Rotton (1997). One of the most interesting results in that study was the presence of a curvilinear function only when 3-hour periods of data were examined. The curvilinear relationship shrank to nonsignificance when the data were aggregated over the
24-hour intervals used in previous studies. Unlike the ecological fallacy, which has received a considerable amount of attention, the question of the most appropriate unit of analysis in a temperature-violence study has not been addressed. Thus, a subsidiary aim of this research was to determine if similar results would be obtained after the data had been aggregated over 6-hour intervals.

Temperature may exert direct as well as indirect effects on behavior, as Rotton’s (1986) redux model suggests. Although we suspect that social contact is often responsible for relationships between temperature and violence, we are reluctant to dismiss research that implicates psychological states, such as negative affect and arousal, as explanations for relationships in this area (Bell & Greene, 1982; Berkowitz, in press). The relationship between temperature and assaults may be one of partial mediation, as shown in the second
diagram (partial mediation) in Figure 1. It could be argued that a more complete model of temperature-violence relations would include arousal and negative affect as mediators, which would give rise to a multiple-mediator model (e.g., Aldwin & Revenson, 1987). However, those who favor psychological mediator theories have not suggested ways to extract data on such mediators from archival records. Therefore, psychological states are grouped together with other unknown causes.

As the third diagram (moderation) in Figure 1 suggests, Cohn and Rotton (1997) found that relationships between temperature and violence depended on time of day and day of the week. Although relationships between temperature and violence are generally linear, Rotton and Cohn (1999a) pointed out that there are times (specifically, between the hours of 3:00 and 6:00 p.m.) when assaults reached a peak at moderately high temperatures and then declined.

Finally, combining the results from Cohn and Rotton (1997) with the extension of social contract theory outlined here, we hypothesized that a model of mediated moderation is needed to capture the complexities of relationships between temperature and violence. If one excludes a study by Lepore, Evans, and Schneider (1992), there are few examples of mediated moderation in the environment-and-behavior literature. As the fourth diagram in Figure 1 suggests, we expect that temperature’s interactions with temporal variables will be greatly reduced and may even vanish after we control for our indicator of social contact. Furthermore, we anticipate that an analysis of simple slopes (which is required by moderation) will reveal that relationships between temperature and assaults vanish during some periods (e.g., late hours of the night and on week days) when we control for levels of social contact; however, at other times (e.g., evening hours and on weekends), temperature will exert effects on violence that cannot be explained in terms of social contact. Rotton and Cohn (2000) have speculated that relationships between temperature and aggression are more likely to be enhanced by alcohol consumption during evening and nighttime than daylight hours.

METHOD

This analysis combines unpublished data on disorderly conduct with published data on assaults (Cohn & Rotton, 1997) in Minneapolis, Minnesota. During the 2-year period between January 1, 1987, and December 31, 1988, the police department in this city received 36,617 calls about assaults and
159,174 calls about disorderly conduct (i.e., disorders). The data were originally grouped into 3-hour intervals to match records obtained from the National Weather Service (NWS); however, as has been found in past research (U. S. Department of Justice, 1988), most of the calls were logged during late hours of the evening and early hours of the morning. For example, during the period covered by this analysis, 44.67% of assault and 47.17% of the disorderly conduct calls were received between the hours of 9:00 p.m. and 2:59 a.m. Therefore, we grouped the data into four 6-hour intervals (21:00-2:59, 3:00-8:59, 9:00-14:59, and 15:00-20:59).

The data file contained six measures of meteorological conditions. As described in a previous report (Cohn & Rotton, 1997), we dropped precipitation and ceiling because they were badly skewed or collinear with other predictors. We also dropped visibility because it did not attain significance in analyses of individual crimes. The remaining weather variables were temperature ($M = 48.40^\circ F; SD = 23.55$), relative humidity ($M = 65.03\%; SD = 19.73$), wind speed ($M = 9.39kph; SD = 5.03$), and sky cover ($M = 5.60 tenths; SD = 4.19$). To this set we added a sequence variable (from 1 to 2,920) to control for linear trend and dummy variables to control for major holidays, public school closings, and the first day of the month when welfare checks were received. Dummy variables of ones and zeroes were also used to estimate and control for time of day, day of the week, season of the year, and their interactions (Aiken & West, 1991).

As described in Rotton and Frey (1985), seasonal trends were estimated by dividing the year into four quarters. We defined seasons in financial terms (e.g., January-March, April-June), because preliminary analyses disclosed that a grouping that began in January and ended in December explained more variance in disorders ($R^2 = .125$) than one that began in either November ($R^2 = .111$) or December ($R^2 = .124$). Preliminary analyses also disclosed that the computer-aided dispatching equipment used to record calls malfunctioned on six occasions (2.4% of the total series).

RESULTS

DISORDERLY CONDUCT CALLS

Preliminary analyses indicated that the distribution for disorders had coefficients of skew and kurtosis of 2.15 ($Z = 46.72, p < .001$) and 6.50 ($Z = 70.70, p < .001$), respectively. A logarithmic (log $X + 1$) transformation reduced the
coefficient for skew to .11 (Z = 2.56, p < .01); it reduced the coefficient for kurtosis to –.03 (Z = –.02).

Temporal variables. Following the lead of previous investigators in this area (Harries & Stadler, 1983), we computed Type III sums of squares to assess the significance of main effect and interaction terms. Significant main effects were obtained for time periods, F(3, 2741) = 3,589.58, p < .001, ΔR² = .61; days, F(6, 2741) = 135.61, p < .001, ΔR² = .05; and seasons, F(3, 2741) = 731.29, p < .001, ΔR² = .12. These effects were qualified by interactions between time and day, F(18, 2741) = 52.03, p < .001, ΔR² = .05.; and between time and season, F(9, 2741) = 15.39, p < .001, ΔR² = .01. The interaction between day and season did not attain significance, F(9, 2741) = 1.38, p > .10, nor did the three-way interaction between time, days, and seasons, F < 1.

A positive coefficient for the sequence variable (β =.10) indicated that complaints about disorderly conduct increased over time. This coefficient attained significance after variation due to days, time, seasons, and their interactions had been partialled out, t(2,740) = 11.30, p < .001. The dummy variables for school closings, major holidays, and first of the month also attained significance when they were added to the prediction equation as a block, F(3, 2737) = 30.41, p < .001. Police received more reports when schools were closed than when they were open (Ms = 84.37 vs. 76.27), t(2,737) = 8.46, p < .001. Also, more complaints were received on the first than on other days of the month (Ms = 84.57 vs. 75.57), t(2,737) = 3.74, p < .001. Interestingly, fewer reports were received on major holidays than other days (Ms = 74.97 vs. 76.31), t(2,737) = –2.88, p < .01.

Weather. The temporal variables described in the previous section explained 85.7% of the variance in disorderly conduct; weather variables explained another 2.8% of the variance, F(4, 2775) = 108.05, p < .001. However, the residuals from this analysis were not independent, as evidenced by a Durbin-Watson d-statistic of 1.63, p < .001. We addressed this problem by employing Prais-Winsten’s algorithm to obtain generalized least squares (GLS) estimates of the regression coefficients (Greene, 1990). The coefficients in Table 1 were obtained by dropping those periods with missing scores. From the coefficients obtained on the first step, it can be seen that disorders were negatively correlated with relative humidity and wind speed. A positive coefficient was obtained for temperature, but this result was qualified by a negative coefficient when temperature’s quadratic component was added to the equation. As the negative sign for this coefficient implies, disorders were an inverted U-shape function of temperature (see Figure 2).
**TABLE 1**
Generalized Least Squares Coefficients for Meteorological Variables Predicting Complaints About Disorderly Conduct (controlling for 115 temporal variables)

<table>
<thead>
<tr>
<th>Predictor</th>
<th>b</th>
<th>β</th>
<th>t</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind speed</td>
<td>-0.00276</td>
<td>-0.04</td>
<td>-6.06***</td>
<td>-0.11</td>
</tr>
<tr>
<td>Sky cover</td>
<td>-0.00048</td>
<td>-0.01</td>
<td>-0.84</td>
<td>-0.02</td>
</tr>
<tr>
<td>Humidity</td>
<td>-0.00047</td>
<td>-0.03</td>
<td>-3.25**</td>
<td>-0.06</td>
</tr>
<tr>
<td>Temperature (T)</td>
<td>0.00381</td>
<td>0.32</td>
<td>24.27***</td>
<td>-0.42</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T</td>
<td>0.00339</td>
<td>0.24</td>
<td>17.34***</td>
<td>0.31</td>
</tr>
<tr>
<td>T²</td>
<td>-0.00002</td>
<td>-0.04</td>
<td>-5.64***</td>
<td>-0.11</td>
</tr>
</tbody>
</table>

NOTE: Degrees of freedom on the first and second steps are 2,732 and 2,731, respectively. Effect size: $r = \frac{t}{(t^2 + df)^{1/2}}$

**TABLE 2**
Disorderly Conduct Complaints as a Function of Temperature (T) and Season of the Year (controlling for 115 temporal variables and 4 other weather variables)

<table>
<thead>
<tr>
<th>Season</th>
<th>b</th>
<th>β</th>
<th>t</th>
<th>r</th>
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<tbody>
<tr>
<td>Winter</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Step 1 (T)</td>
<td>0.003844</td>
<td>0.27</td>
<td>13.20***</td>
<td>0.24</td>
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<tr>
<td>Step 2 (T)</td>
<td>0.004677</td>
<td>0.33</td>
<td></td>
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<tr>
<td>T²</td>
<td>0.000015</td>
<td>0.03</td>
<td>1.09</td>
<td>0.02</td>
</tr>
<tr>
<td>Spring</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Step 1 (T)</td>
<td>0.003097</td>
<td>0.22</td>
<td>9.01***</td>
<td>0.17</td>
</tr>
<tr>
<td>Step 2 (T)</td>
<td>0.006524</td>
<td>0.46</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T²</td>
<td>-0.000130</td>
<td>-0.25</td>
<td>-7.78***</td>
<td>-0.15</td>
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<tr>
<td>Summer</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Step 1 (T)</td>
<td>0.001756</td>
<td>0.12</td>
<td>3.56***</td>
<td>0.07</td>
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<tr>
<td>Step 2 (T)</td>
<td>0.006127</td>
<td>0.43</td>
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<tr>
<td>T²</td>
<td>-0.000098</td>
<td>-0.19</td>
<td>-3.51***</td>
<td>-0.07</td>
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<tr>
<td>Fall</td>
<td></td>
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<tr>
<td>Step 1 (T)</td>
<td>0.005191</td>
<td>0.36</td>
<td>14.98***</td>
<td>0.28</td>
</tr>
<tr>
<td>Step 2 (T)</td>
<td>0.005016</td>
<td>0.35</td>
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<tr>
<td>T²</td>
<td>-0.000007</td>
<td>-0.01</td>
<td>-0.42</td>
<td>-0.01</td>
</tr>
</tbody>
</table>

NOTE: Degrees of freedom are 2,729 and 2,725 for linear and quadratic trends, respectively.

***$p < .001$. **$p < .01$. *

*Moderators of temperature-violence relations.* Following procedures described in Aiken and West (1991), we assessed two-way interactions by first centering temperature and then multiplying the resulting deviation...
scores by the indicators for each set of temporal variables (days, time periods, and seasons). Significant effects were obtained for temperature’s interaction with season of the year, $F(6, 2708) = 8.20, p < .001$, and time of day, $F(6, 3708) = 3.05, p < .01$. Temperature’s interaction with days of the week did not attain significance, $F < 1$.

Table 2 summarizes tests on the simple slopes for temperature during each season. Although disorders were a linear function of temperature during fall and winter months, the quadratic trend also attained significance during spring and summer months. The negative coefficient for these tests indicates that disorders declined after reaching a peak at moderately high temperatures.

The tests summarized in Table 3 indicate that disorders were a linear function of temperature between the hours of 3:00 and 8:59 a.m., but they were a curvilinear function during other hours of the day. The negative coefficients indicate that disorders were an inverted U-shaped function of temperature during daylight hours (i.e., 9:00 a.m. to 8:59 p.m.) In contrast, the positive coefficient for the quadratic trend indicate that disorders were an accelerated function of temperature between the hours of 9:00 p.m. and 2:59 a.m.

These results appear to be generalizable, because temperature’s interaction with days, time, and seasons did not attain significance: For Season ×
As previously noted, one of the goals of this investigation was to determine if the results that Cohn and Rotton (1997) obtained for 3-hour intervals could be extended to 6-hour periods of time. Thus, it is reassuring to note that results summarized in the first part of Table 4 are very similar to ones that Cohn and Rotton presented for 3-hour intervals.

In particular, temperature’s linear and quadratic trends attained significance when the afternoon interval was expanded from the 3-hour interval between 3:00 and 5:59 p.m. to the six hours between 3:00 and 8:59 p.m.

As we expected, the presumed mediator (disorders) was correlated with assaults, \( r = .33 \), even after temporal variables and their interactions were partialled out. From the results summarized in the second part of Table 4, it can be seen that the coefficient for temperature’s linear component was reduced but retained its significance after the disorder variable was added to the equation. This result is consistent with a model of partial mediation; that is, temperature exerts direct as well as indirect (disorder-mediated) effects on assaults.
assaults. In contrast, including disorders reduced temperature’s quadratic component to a value that is clearly nonsignificant. This result implies that social contact (as operationalized by disorders) was responsible for the curvilinear relationship between temperature and assaults.

MEDIATED MODERATION

Time periods. Temperature’s interaction with time of day attained significance, $F(6, 2708) = 16.37, p < .001$, when it was evaluated after all other variables had been forced into the prediction equation (i.e., Type III SS). From the tests summarized in the top half of Table 5, it can be seen that assaults were a positively accelerated (U-shaped) function of temperature during nighttime hours (between 9:00 p.m. and 2:59 a.m.) and a linear function during morning hours (between 3:00 and 8:59 a.m.). Interestingly, temperature and violence were not related during the warmest hours of the day (9:00 a.m. to 2:59 p.m.). Finally, as the negative sign for temperature’s quadratic

### TABLE 4

<table>
<thead>
<tr>
<th>Predictor</th>
<th>$b$</th>
<th>$\beta$</th>
<th>$t$</th>
<th>$r$</th>
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<td>Direct effects</td>
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<td>Step 1</td>
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<tr>
<td>Wind speed</td>
<td>-0.03296</td>
<td>-0.03</td>
<td>-2.73**</td>
<td>-0.05</td>
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<tr>
<td>Sky cover</td>
<td>-0.028015</td>
<td>-0.02</td>
<td>-1.86</td>
<td>-0.04</td>
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<td>Humidity</td>
<td>-0.000554</td>
<td>-0.00</td>
<td>-0.14</td>
<td>-0.00</td>
</tr>
<tr>
<td>Temperature (T)</td>
<td>0.050148</td>
<td>0.21</td>
<td>11.49***</td>
<td>0.21</td>
</tr>
<tr>
<td>Step 2</td>
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<tr>
<td>T</td>
<td>0.023516</td>
<td>0.10</td>
<td>5.00***</td>
<td>0.10</td>
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<td>$T^2$</td>
<td>-0.000062</td>
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<td>Indirect effects</td>
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<td>Step 1</td>
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<tr>
<td>Disorders</td>
<td>6.785532</td>
<td>0.38</td>
<td>14.22***</td>
<td>0.26</td>
</tr>
<tr>
<td>T</td>
<td>0.024471</td>
<td>0.11</td>
<td>5.45***</td>
<td>0.10</td>
</tr>
<tr>
<td>Step 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disorders</td>
<td>6.746638</td>
<td>0.38</td>
<td>14.05***</td>
<td>0.26</td>
</tr>
<tr>
<td>T</td>
<td>0.023516</td>
<td>0.10</td>
<td>5.00***</td>
<td>0.10</td>
</tr>
<tr>
<td>$T^2$</td>
<td>-0.000066</td>
<td>-0.01</td>
<td>-0.69</td>
<td>-0.01</td>
</tr>
</tbody>
</table>

NOTE: Degrees of freedom on the first and second steps are 2,732 and 2,731 for linear and quadratic trends, respectively, under direct effects and 2,731 and 2,730 for linear and quadratic trends, respectively, for indirect effects.

**$p < .01$. ***$p < .001$. **
component implies, assaults were an inverted U-shaped function of violence during late afternoon and early evening hours. This last finding extends Cohn and Rotton’s (1997) findings, which were based on 3-hour intervals. This analyses indicates that an inverted U-shaped curve also describes the relationship when the interval is expanded to include the 6-hour period between 3:00 and 8:59 p.m.

Temperature’s interaction with time retained its significance, $F(6, 2707) = 15.58, p < .001$, after disorders were added to the prediction equation. However, referring to tests summarized in the bottom half of Table 5, it can be seen that disorders mediated the relationship between temperature and assaults during the early morning hours between 3:00 and 8:59 a.m. The results summarized in the table suggest that disorders were also responsible for the two curvilinear relationships (i.e., the positive one during late evening hours and the negative one during afternoon and early hours of the evening).

**TABLE 5**

Moderated Mediation Analysis of Assaults as a Function of Temperature and Time (controlling for 115 temporal and 3 other weather variables)

<table>
<thead>
<tr>
<th>Period</th>
<th>Trend</th>
<th>b</th>
<th>β</th>
<th>t</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Direct effects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21:00-2:59</td>
<td>Linear</td>
<td>0.11838</td>
<td>0.50</td>
<td>14.56***</td>
<td>0.27</td>
</tr>
<tr>
<td></td>
<td>Quadratic</td>
<td>0.00048</td>
<td>0.05</td>
<td>2.31*</td>
<td>0.04</td>
</tr>
<tr>
<td>3:00-8:59</td>
<td>Linear</td>
<td>0.02875</td>
<td>0.11</td>
<td>3.53***</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>Quadratic</td>
<td>0.00005</td>
<td>0.01</td>
<td>0.28</td>
<td>0.01</td>
</tr>
<tr>
<td>9:00-14:59</td>
<td>Linear</td>
<td>0.01271</td>
<td>0.05</td>
<td>1.79</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>Quadratic</td>
<td>−0.00020</td>
<td>−0.02</td>
<td>−1.27</td>
<td>−0.02</td>
</tr>
<tr>
<td>15:00-20:59</td>
<td>Linear</td>
<td>0.05776</td>
<td>0.24</td>
<td>7.84***</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>Quadratic</td>
<td>−0.00050</td>
<td>−0.06</td>
<td>−2.88**</td>
<td>−0.06</td>
</tr>
<tr>
<td><strong>Indirect effects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21:00-2:59</td>
<td>Linear</td>
<td>0.09692</td>
<td>0.42</td>
<td>10.13***</td>
<td>0.19</td>
</tr>
<tr>
<td></td>
<td>Quadratic</td>
<td>0.00037</td>
<td>0.04</td>
<td>1.84</td>
<td>0.04</td>
</tr>
<tr>
<td>3:00-8:59</td>
<td>Linear</td>
<td>−0.00005</td>
<td>−0.00</td>
<td>−0.00</td>
<td>−0.00</td>
</tr>
<tr>
<td></td>
<td>Quadratic</td>
<td>0.00007</td>
<td>0.01</td>
<td>0.42</td>
<td>0.01</td>
</tr>
<tr>
<td>9:00-14:59</td>
<td>Linear</td>
<td>−0.00701</td>
<td>−0.03</td>
<td>−1.00</td>
<td>−0.02</td>
</tr>
<tr>
<td></td>
<td>Quadratic</td>
<td>0.00001</td>
<td>0.00</td>
<td>0.06</td>
<td>0.00</td>
</tr>
<tr>
<td>15:00-20:59</td>
<td>Linear</td>
<td>0.03507</td>
<td>0.15</td>
<td>4.81***</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>Quadratic</td>
<td>−0.00021</td>
<td>−0.02</td>
<td>−1.26</td>
<td>−0.02</td>
</tr>
</tbody>
</table>

Note: Degrees of freedom on the first and second steps are 2,728 and 2,725 for linear and quadratic trends, respectively, under direct effects and 2,728 and 2,724 for linear and quadratic trends, respectively, for indirect effects.

*p < .05. **p < .01. ***p < .001.
Days of the week. Consistent with theories that emphasize social contact, assaults were more strongly correlated with temperature on Fridays, Saturdays, and Sundays than other days of the week.\textsuperscript{11} Temperature’s quadratic component attained significance on only 1 day (Thursday). This is to be expected, because these analyses were based on data aggregated over 24-hour intervals; as Rotton and Cohn (1999a) have shown, this type of aggregating masks curvilinear relationships that were observed during specific time periods. In addition, as social contact models predict, the quadratic trend observed on Thursday shrank to nonsignificance when we controlled for complaints about disorderly conduct, as did the linear trends on Mondays through Thursdays.

Seasons of the year. Perhaps the strongest evidence for mediated moderation was obtained when we examined temperature’s interaction with season of the year, $F(6, 2708) = 2.44, p < .05$. As Figure 3 suggests, assaults were a linear function of temperature during winter and fall months and a quadratic function during spring and summer months. However, the interaction shrank to nonsignificance when we controlled for complaints about disorderly conduct, $F(6, 2707) = 1.05, p > .30$.
Triple interactions. Nonsignificant results were obtained when we expanded our analyses to include the triple interactions of temperature with day and time periods, $F < 1$, day and seasons, $F < 1$, and time and seasons, $F(36, 3618) = 1.07, p > .30$.

DISCUSSION

This study’s results extend prior research on weather variables and violence in several ways. First, they indicate that the nonlinear trends observed by Cohn and Rotton (1997) were not limited to the 3-hour period between 3:00 p.m. and 6:00 p.m. Temperature’s quadratic trend also attains significance when the data are aggregated over 6-hour periods of time.

Second, we have introduced a new measure (disorderly conduct) that is very sensitive to both temporal variables and meteorological conditions. Although this study’s aims were primarily theoretical, it is worth noting that the Minneapolis police department received more calls about disorderly conduct than any other crime or problem. This finding is consistent with the emphasis that RA theory places on everyday behavior. Although movies and television highlight dramatic events, analyses of police activities (e.g., Scott, 1981) make it clear that police officers spend the majority of their time dealing with order maintenance problems, such as complaints about barking dogs and noisy neighbors.

However, this study’s most important finding is theoretical: The results are consistent with a model of mediated moderation. It appears that temperature exerts direct and indirect effects on assaults, and that the latter are mediated by a measure of social contact (namely disorderly conduct). In particular, nonlinear relationships between temperature’s quadratic component and assaults were greatly reduced and sometimes even disappeared when we included disorders in our prediction equation. This finding suggests that the NAE model should be expanded to include avoidance behavior; that is, as we have observed, individuals not only try to escape from hot and cold settings, they also engage in behavior that allows them to avoid extreme temperatures. In keeping with RA theory’s emphasis on primary territories, we suspect that extreme temperatures reduce people’s willingness to venture away from their home or place of work, which reduces the amount of time that they spend in either secondary territories (e.g., bars and taverns) or public territories (e.g., alleys and street corners), where they would come into contact with aggressive offenders. This suspicion is supported by the fact that
87% of stranger-based assaults occur away from home (U.S. Department of Justice, 1988).

It might be objected that temperature also exerted direct (unmediated) effects on assaults. Interestingly, most of the direct effects are observed during the late evening hours and on weekends. This pattern is similar to one we have observed in Dallas: Although relationships between temperature and assaults were curvilinear during daylight hours, as the NAE model predicts, the results were dominated by linear relationships during evening and nighttime hours. This finding led Rotton and Cohn (1999b) to suggest that the NAE model should be extended to include alcohol consumption as an escape behavior; that is, heat causes thirst, and drinking behavior can be regarded as a means of escaping the discomfort caused by high temperatures.

Although this study provides a surprising high degree of support for the social contact hypothesis, we need to be mindful of its limitations. Perhaps the most obvious limitation of this study’s findings is that they are based on correlational data. It is only because we adopted the logic of path analysis that we have used words (direct and indirect effects) that imply that anything more than correlational relations can be inferred from our methods and procedures. We believe that research on weather variables allows us to place greater confidence in our conclusions than the ones typically possible when working with correlational data, because reverse causation is not a serious rival hypothesis for effects attributed to temperature (obviously, changes in the rate of disorders in a community do not cause changes in temperature). However, the same cannot be said about the correlation between disorderly conduct and assaults. Although the possibility seems remote, it is possible that disorderly conduct events occurred as a form of citizen response to the occurrence of, or the police department’s handling of, instances of assault.

Another factor that limits our ability to generalize our findings is our use of econometric procedures for examining relations between time series. It might be objected that more definitive conclusions could have been drawn if we had taken advantage of the longitudinal nature of the data to examine relationships after supposed causes had been lagged, because temporal precedence is a necessary (although by no means sufficient) condition for inferring causation (Cook, Dintzer, & Mark, 1980). Time-series analyses allows investigators to determine if changes in weather variables precede and predict subsequent behavior (Rotton & Frey, 1985). Unfortunately, we have had little success in developing the models necessary for establishing temporal precedence.

Finally, it might be thought that we have committed the ecological fallacy of drawing conclusions about the behavior of individuals on the basis of
correlations among aggregate variables (Firebaugh, 1978; Greenland & Morgenstern, 1989; W. Robinson, 1950). There are two ways to address this concern. First, we are not claiming that social disorders and assaults involve the same people. Indeed, we would be surprised if the same parties were involved, because dispatchers usually record the most serious offense received in each call. The relationship between disorders and assaults in this study is structural; as such, it is similar to the relationship between percent unemployed and rates of homicide. As Archer and Gartner (1984, p. 158) remind us, “it cannot be assumed that the individuals involved in offenses are themselves unemployed.” Our mediational model is probabilistic (i.e., it applies to all of the people living in a neighborhood or city). If a certain temperature increases the probability of disorderly behavior, then it is more likely that an assault victim will have been involved in an episode of disorderly conduct even if it is not the same episode that the police investigated. Second, we believe that an imperfect measure of a supposed mediator is to be preferred over having no measure at all. Our approach contrasts with that of theorists (Anderson & Anderson, 1998) who have speculated about psychological states, such as negative affect, but who have not assessed supposed mediators of temperature-aggression relations in extra-laboratory settings. This does not mean that we are denying that relationships between temperature and violence might also be mediated by negative affect. This possibility is implied by the arrow from temperature to assaults in our model of mediated moderation shown in Figure 1. However, this possibility is based on the results of laboratory studies. To date, investigators in this area have not collected measures of emotional states that would allow them to conclude that relationships between outdoor temperatures and real-world violence are, in fact, mediated by affective states.

Despite these limitations, we believe that this study’s results advance research on weather and behavior in at least two ways. First, they identify a measure that appears to be more sensitive to temporal and meteorological variables than criminal behavior, such as assaults. In this regard, it is perhaps worth noting that our predictors explained considerably more variance in disorders ($R^2 = .87$) than in assaults ($R^2 = .76$). This finding provides some justification for research aimed at finding out how weather affects more mundane, everyday sorts of behavior. Research is needed to quantify how often individuals affiliate on cold, warm, and hot days. Second, as we have previously suggested, more than one theory is needed to understand the complexities of weather-aggression interactions; as Rotton and Cohn (1999a, p. 1328) suggested, “it is only combining several theories of aggression that we can begin to make sense of how the relation between heat and aggression varies over time.” It is easy to fall into the trap of championing one theory to the
exclusion of all other models and theories. We hope that the results of this investigation illustrate the advantages of integrating principles from what are commonly considered sociological and psychological theories. Further progress in this area depends on psychologists expanding their models to include the social consequences of affective states and criminologists broadening their theories to include emotions that promote and inhibit social contact.

NOTES

1. It can be argued that there are times when aggression does not require contact. Examples include missiles, sniper fire, and letter bombs. Fortunately, however, these acts occur so infrequently that they can be consigned to the role of unmeasured residuals in models of violence.

2. It is not enough to assert that informed consent procedures allow participants to avoid unpleasant conditions. Research on the-foot-in-the-door technique (Freedman & Fraser, 1966) highlights pressure to remain in an experiment after participants have arrived at the laboratory.

3. It should be cautioned that the disorder concept has evolved over time. It was once used by Taylor (1987) and other theorists to describe a continuum that ranged from environmental conditions (e.g., vacant housing) to serious crimes (violence). More recent analyses suggest that the term encompasses social and physical incivilities, such as “groups of rowdy teens, public drunkeness, public drug use or sales, people fighting, street hassles, prostitution, aggressive pan-handling . . . graffiti, litter, and abandoned cars” (Taylor, 1999, p. 65).

4. The major holidays are listed in Cohn and Rotton (1997); the control variable for local festivals was dropped because it did not attain significance in previous analyses.

5. It might be said that it is the distribution of residuals rather than observed scores that matters. Subsidiary analyses disclosed that the coefficients of skew and kurtosis were even higher for the residuals, skew = 3.32 (Z = 72.09) and kurtosis = 59.20 (Z = 643.47) in the analyses that controlled for temporal and weather variables.

6. Type III sums of squares (SS) are adjusted for effects at the same or lower levels of analyses. Thus, each main effect is adjusted for the other two main effects (e.g., time adjusted for days and seasons, days adjusted for times and seasons), each two-way interaction is adjusted for the other interactions as well as main effects (e.g., Time × Day adjusted for time, day, seasons; Time × Season; and Day × Season), and the three-way interaction is adjusted for lower interactions. It is for these reasons that increments rather than total variances (i.e., ∆R² rather than R²) are reported.

7. A copy of tables that give means and the results of Bonferroni multiple comparisons between means involved in each interaction may be obtained from the first author.

8. The fact that temporal variables left very little variance to be explained raises the possibility that they acted as suppressors (Pedhazur, 1982). However, a subsidiary analysis indicated that temperature’s linear and quadratic components also attained significance when they were
entered before the temporal variables: \( t(2,849) = 17.73, p < .001 \) for the linear component and \( t(2,848) = -4.31, p < .001 \) for the quadratic component. In a related vein, it has been suggested (Anderson & Anderson, 1998) that months and temperature are too highly correlated (i.e., multicollinear) to be used as predictors in the same analysis. However, variance inflation factors of temperature’s linear and quadratic components were 4.63 and 1.52 when they were evaluated after temporal variables had been included in our prediction equations. These values are considerably lower than the figure (namely, 10) that Neter, Wasserman, and Kutner (1990) suggest as a cause for concern.

9. We performed subsidiary analyses in which 71 missing scores were replaced via linear interpolation at a point (from the last observed score to the next observed score). Doing so yielded results that were almost identical to the ones described here that were obtained when we followed the more conservative procedure of simply dropping time periods on which a score was missing.

10. The assault series was also skewed and kurtotic; for skew and kurtosis, we obtained coefficients of 3.32, \( Z = 72.09, p < .001 \), and 58.29, \( Z = 643.47, p < .001 \), respectively. Following Cohen and Cohen (1983), who recommended a square root transformation for rates and proportions, we were able to reduce the coefficient for skew to .32, \( Z = 7.00, p < .001 \), and the coefficient for kurtosis to .31, \( Z = 3.48, p < .001 \). However, there are two reasons why we have chosen to present results based on the original (untransformed) series for assaults rather than the ones based on a square root transformation. First, the results presented here are very similar to the results obtained after the square root transformation had been applied. Second, working with untransformed scores makes it easier to compare and extend the results from this analysis with the findings reported in Cohn and Rotton’s (1997) report.

11. A table of regression coefficients and tests of significance for temperature’s linear and quadratic components on each day of the week may be obtained from the first author.

12. The nonsignificant interaction for Day \( \times \) Time \( \times \) Temperature contrasts with the significant one described in Cohn and Rotton (1997). We suspect that its significance in the previous report can be traced to a few outliers that acted as “influential cases” when data were aggregated over brief (3-hour) intervals. This suspicion is supported by the fact that the interaction described in Cohn and Rotton (1997) also did not attain significance, \( F(84, 5504) = 1.26, p = .06 \), when we used a square root transformation to reduce the outliers’ influence.

13. The first step in establishing temporal precedence is to develop an autoregressive integrative moving average model (Box, Jenkins, & Reinsel, 1994). Such models are typically accepted when their residuals resemble white noise as indexed by (a) nonsignificant autocorrelations when residuals lagged two time periods and (b) a global chi-squared that does not attain significance when the data are lagged a substantial (20-30) number of periods (McCleary & Hay, 1980). We have not yet been able to develop Autoregressive Integrated Moving Average (ARIMA) models for 6-hour data sets that pass the second of these two tests. Rotton and Cohn (1999b) have recently presented models that pass these tests when this data set is aggregated over 12-hour intervals.

REFERENCES


