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A Stab in the Dark?: A Research Note on Temporal Patterns of Street Robbery

Lisa Tompson[1] and Kate Bowers[1]

Abstract

Objectives: Test the influence of darkness in the street robbery crime event alongside temperature. *Methods:* Negative binomial regression models tested darkness and temperature as predictors of street robbery. Units of analysis were four 6-hr time intervals in two U.K. study areas that have different levels of darkness and variations of temperature throughout the year. *Results:* Darkness is a key factor related to robbery events in both study areas. Traversing from full daylight to full darkness increased the predicted volume of robbery by a multiple of 2.6 in London and 1.2 in Glasgow. Temperature was significant only in the London study area. Interaction terms did not enhance the predictive power of the models. *Conclusion:* Darkness is an important driving factor in seasonal variation of street robbery. A further implication of the research is that time of the day patterns are crucial to understanding seasonal trends in crime data.

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Introduction

The relationship between behavior and the seasons has been contemplated since records began[1] (Harries, Stadler, and Zdorkowski 1984; Wolfgang 1958). As such, the seasonality of criminal behavior has been well chronicled throughout criminological history (see Baumer and Wright 1996 for an extensive coverage). Despite an impressive corpus of research over the past two centuries, no universal trends have yet emerged on the seasonality of specific crime types (Block 1984; McDowall, Loftin, and Pate 2011; Yan 2004).

The quintessential question is why seasonal variations in crime exist or exhibit the particular nuances that they do. The tradition to date has been to adopt theories relating to weather—either the physiological effect of temperature (see Anderson et al. 2000 for a good summary) or the social effect of weather on the routine activities of people (Felson 1987). Seasons are a socially constructed category defined by a combination of hours of daylight and temperature. This article extends the knowledge base on factors influencing temporal rhythms in crime by considering the role played by darkness in the crime event. Although this meteorological variable has been theorized as being relevant to the opportunity structure for commercial robbery (Landau and Fridman 1993; Van Koppen and Jansen 1999) and residential burglary (Coupe and Blake 2006), it has not been explicitly tested for street robbery (which is different from commercial robbery in several respects). This article aims to address this gap and ultimately argues that darkness is an important driving factor in seasonal variation of street robbery.

We begin by briefly reviewing the literature, then we describe the data and the analytic strategy, present the results, and in the discussion we outline implications of the findings.

Darkness as an Inhibitor of Guardianship

The routine activity approach (Felson 1987) asserts that the convergence of a motivated offender with a suitable target—crucially, in the absence of a capable guardian—creates favorable conditions for a crime to occur. People's

everyday routine activities explain how victims and offenders' paths overlap, both spatially and temporally, to create a tapestry of criminal opportunities.

Guardianship is commonly seen as the critical ingredient in understanding why crime concentrates relative to space and time (Eck and Weisburd 1995; Felson 1995; Reynald 2010). The capability of guardians to monitor their surroundings—regardless of whether this is intentionally performed— is intrinsically linked to their surroundings being observable. The opportunities for observation are wholly dependent on the physical environment. Certain situational conditions facilitate the observation of people and places, others inhibit. The defensive space literature (Newman 1972; Perkins, Meeks, and Taylor 1992) is replete with examples of the built environment that have been found to assist or hinder natural surveillance.

Lighting conditions have an obvious bearing on observation activities. Poor lighting conditions, whether they are due to weather variables (e.g. poor visibility or heavy rain) or the absence of the sun's light, could be a significant obstacle to surveillance and thus have an effect on guardianship, and as a corollary, crime. Coupe and Blake's (2006) work demonstrated that some residential dwellings are excellent daytime targets for burglars while simultaneously being poor targets in the nighttime. Burglars who operated in the daylight were more likely to select unoccupied targets (residences) with better front cover (i.e., obstruction of sightlines from the front) and also employed different modus operandi from those operating in darkness. The nighttime availability of guardians in occupied dwellings did not deter some burglars, as the darkness prevented them from being capable of monitoring their surroundings.

Further to this, Rotton and Kelly stress that darkness affords offenders the advantageous conditions of anonymity; darkness is ''deindividuating'' (1985:288). Considered in this way, darkness weakens the ability of guardians to identify potential offenders; they cannot distinguish them from other community members in the dark. Hence darkness can be thought of as a key inhibitor to capable guardianship.

Few studies have empirically examined the relationship between crime levels and darkness. Heller and Markland (1970) included hours of sunlight in their analysis of calls for service incidents but found it to be less influential than the daily average temperature. Lab and Hirschel (1988) attempted to control for lighting conditions in their research on crime and weather by constructing four sets of 6-hr intervals, approximating shifts in daylight and darkness hours. They found the relationship between temperature and assaults was consistent during the day and at night. Cohn (1993) found that darkness was highly related to rape and domestic violence.

The challenge to date has been disentangling the effect of temperature from that of darkness. Temperatures peak and drop throughout the course of the day—often, but not always, corresponding with sunrise and sunset. Prior research has suggested that there is a curvilinear relationship between temperature and violent crime (Rotton and Cohn 2000), whereby extremes in temperature—cold or hot—reduce the likelihood of incidents. Whether this is attributable to physiological changes in the individual or the limitation of social contact between people is not yet clear.

The Seasonality of Robbery

Previous research on the seasonality of robbery has tended to find that both street and commercial robbery peak volumetrically in the winter months (DeFronzo 1984; Deutch 1978; Field 1992; Michael and Zumpe 1983). This trend is not though consistent across different locales and constructs of criminal behavior (for contrasting trends see Block 1984; Cohn and Rotton 2000; Sorg and Taylor 2011). Several explanations have been advanced for this seasonal increase in robberies. Winter is, in most cultures, more economically demanding. It is a time when the cost of living is higher and unemployment rates may be greater (Cohn 1990; Landau and Fridman 1993; Sutherland 1947). Both of these conditions may produce a greater number of motivated offenders. Contemporaneously, the Christmas holiday period in western cultures produces a heightened availability of cash and desirable goods in society (in buildings and on people) and thus is theorized to create more suitable targets (Field 1992).

The final common explanation of the winter peak in robberies is that the environmental conditions—such as darkness—in winter might facilitate robbery (Landau and Fridman 1993). Using the premise that darkness is important to the opportunity structure, Van Koppen and Jansen (1999) found there was a near symmetrical monthly pattern of commercial robberies either side of the winter solstice.[2] This sharp peak in winter offending was attributable to an increase of robberies committed in the evening hours (between 4.26 p.m. and 10.02 p.m.—the sunset times in midwinter and midsummer). Stepwise regression analysis was performed to test whether these differences in the monthly variation of robbery still held when the effects of weekdays, national holidays, hours of daylight, school holidays, and weather variables were accounted for. The results led Van Koppen and Jansen to conclude that "the winter peak in robberies can better be explained by the dark hours during the evening than by other possible factors" (1999:25). These findings lend credence to the standpoint that darkness is a facilitating environmental condition

for commercial robbery. Commercial robbery has the constraint that it can only occur while the target establishment is open. This is not the case for street robbery that happens throughout the day. Whether the influence of darkness is a key indicator of levels of street robbery has been unaddressed by the research community until now.

The Current Research

The objective of this research is to compare to what extent the situational variables temperature and darkness predict the frequency of street robbery. We previously conjectured that temperature and darkness may co-vary considerably. If correct, as variables they might approximate each other. We therefore believe it important to assess the degree of association between these variables and the consequent relationship this has with levels of street robbery.

The greatest contrast between summer and winter months in the United Kingdom in terms of lighting, and quite possibly temperature, is between 4 p.m. and 10 p.m. This period is distinguishable, as it is when people are primarily engaging in discretionary routine activities, as opposed to obligatory activities (see LeBeau 1994; LeBeau and Corcoran 1990), and this is true for all days of the week. We think that this temporal window contains unique qualities that relate to temperature, darkness, and behavior, and we therefore ensured that this was included as a discrete unit of analysis. The unit of analysis is in fact an important feature of the current study. To the authors' knowledge, prior research has rarely accounted for different periods of the day and has more commonly used the *week*, the *month*, or even the *year* (Van Koppen and Jansen 1999). In their study on commercial robbery, Van Koppen and Jansen used the day as the unit of their analysis, with the number of minutes of daylight across the day as an independent variable. Here, we use the *shift* as the unit of analysis; subdividing the day into four distinct time intervals and establishing the count of robbery in each shift over an extended time period. We also calculate a distinct estimate of darkness for each individual shift in our time series. This allows a more direct test of the influence of darkness— we are attempting to predict the number of robberies in the particular shift that has a certain amount of darkness and not purely trying to predict the number of robberies across the entire day. This should help protect the analysis from the effects of potential temporal aggregation bias or the modifiable temporal unit problem (Dorling and Openshaw 1992).

Street robbery has been chosen in this research for several reasons. First, robbery is serious enough to warrant police attention and prioritization, and this means that it is generally recorded with good temporal precision

(notwithstanding the well-rehearsed limitations of police recorded crime data as summarized by Maguire (2007)). Thus, as a crime type it is more amenable to precise analysis on temporal patterns than traditional property crime (which might have happened over a large, unknown temporal period). Second, by definition street robbery takes place outside, on the street. These are areas where natural external conditions are dominant and are largely unaffected by artificial situational elements such as heating or air-conditioning (with the exception of street lighting). Third, due to the usual loss of property, victims have more reason to report the crime to the police than if they had been subject to a nonserious violent crime. Recent estimations from the British Crime Survey (based on victimization reports) put the reporting rate in the United Kingdom at around 45 percent for robbery victims (Flatley et al. 2010). Finally, by using only one crime type we are protecting against crime-type heterogeneity, commonly seen in studies on seasonality and crime. While this limits the generalizability of the findings, it also enriches the knowledge base for street robbery, which is seldom studied separately from commercial robbery, despite having very different characteristics.

The specific hypothesis being tested in this article is that the presence of darkness will increase the likelihood of street robbery occurring, when differences in temperature are accounted for.

Data and Analytic Strategy

Street robbery in the United Kingdom is overwhelmingly an urban phenomenon (Flatley et al. 2010), concentrated in metropolitan areas. The study regions used in this analysis feature two major U.K. cities: London and Glasgow. For London, the study area consists of two adjacent policing areas—Camden and Islington. For Glasgow, the study area encompasses the entire region Strathclyde Police are responsible for, which ranges from the main city of Glasgow to the Inner Hebrides. These two U.K. cities constitute a useful contrast and aim to increase the external validity of this research by enabling a comparison of a southern city with a milder climate (London) with one of the U.K.'s largest northern cities where the weather is more variable (Glasgow). Table 1 gives statistics on these variations. Due to their respective latitudes, London and Glasgow have different levels of darkness throughout the year; in summer, there is considerably less darkness in Glasgow than London, in winter there is more. The variability of temperature and rainy days is another noteworthy difference between

Table 1. Descriptive Statistics for Both Study Areas.

	London, England	Glasgow, Scotland
Geographical area	36.5 km^2	13,968.9 km^2
2001 Population	173,884	2,300,000
Population density (km^2)	4763.9	164.6
Latitude	51° 32 N	55° 50 N
Hours of darkness on June 21	5:46	4:21
Hours of darkness on December 22	14:50	15:27
Temperature variation throughout 2002–03 (in °C)	−3 to 36	−11 to 28
Number of rainy days in 2002–03	259	422
2002 Street robbery	3,476	2,270
2003 Street robbery	3,022	1,954
Total robbery	6,511	4,224

these two locales. Further descriptive statistics of these study areas can be found in Table 1.

Recorded street robbery data were acquired from the Metropolitan Police Service and Strathclyde Police for the calendar years 2002 and 2003. This period was selected as it was a period of high volumes of street robbery (which subsequently decreased in both study areas in the following years), and one when data were available for both sites, thus increasing the comparability of the results. Table 1 shows the volume of street robberies in both years. While the two study areas are different in terms of physical size and population (again this illustrates the two contrasting contexts), the number of robberies analyzed are of similar scale (6,511 incidents in London and 4,224 in Glasgow) which is also useful for comparability.

We previously observed that the temporal window of 4 p.m.–10 p.m. represents the greatest variation in darkness over the course of a year. Each robbery event was hence assigned to one of four equal-length 6-hr temporal shifts: 4 a.m.–9.59 a.m.; 10 a.m.–3.59 p.m.; 4 p.m.–9.59 p.m.; and 10 p.m.–3.59 a.m. for each day.

As temporal precision was important, robbery events that were recorded to span more than 4 hr were removed from the data set. This resulted in an overall loss of 92 records[3] (0.9 percent of the overall data set), leaving 10,643 street robbery events across both study areas. For the remaining records, the mean time span was under 5 min, with 97 percent of all events occurring within 30 min. The temporal concentration of the street robbery

Table 2. The Temporal Concentration of Data Across the Two Study Areas.

Site	4 a.m.–9.59 a.m.	10 a.m.–3.59 p.m.	4 p.m.–9.59 p.m.	10 p.m.–3.59 a.m.
London	669 (10.4%)	1,143 (17.7%)	2,083 (32.2%)	2,563 (39.7%)
Glasgow	340 (8.1%)	1,102 (26.3%)	1,529 (36.5%)	1,214 (29.0%)

data into these shifts are shown in Table 2 for both study areas. For London, just less than three-quarters of all robberies fell between 4 p.m. and 4 a.m.; for Glasgow this figure was a little shy of two-thirds.

The dependent variable was the count of street robbery in each temporal shift for each day in the 2-year data period. These event counts best resembled a Poisson distribution and were overdispersed, with the variance greater than the mean (the London data $\mu = 2.22$, $\delta = 3.64$; the Glasgow data $\mu = 1.44$, $\delta = 2.07$). Diagnostic tests[4] revealed that a negative binomial regression model was more appropriate than a regular Poisson regression model to test the hypothesis, since it allows for overdispersion.

Past research on seasonality has been criticized for the indirect measurement of independent variables (Van Koppen and Jansen 1999). For this reason, we chose our constructs of the variables to be as precise as the data would permit. An independent variable representing the presence of darkness was thus created. This was achieved using data on sunrise and sunset[5] to calculate the proportion of darkness hours in each shift for each day. A value of 0 represented no darkness in the shift, a value of 1 represented 6 hr of darkness. Decimal values represented the proportional time when a transition from daylight to darkness (or vice versa) occurred.

Temperature data—in centigrade—were sourced from "Weather Underground"[6] for the nearest airports to the study sites.[7] From these data, each temporal shift was assigned a value based on the best approximation of the typical temperature for each day in the data. For the 10 p.m.–4 a.m. shift, this was the daily minimum, for the 10 a.m.–4 p.m. shift this was the daily maximum, and for the 4 a.m.–10 a.m. and 4 p.m.–10 p.m. shifts this was the daily average. By assigning such values to each shift in the day, we believe we were mitigating the shortcomings of other studies that only used the average daily temperature. As we wished to test the interaction effect of temperature and darkness, we multiplied each temperature value by the proportion of darkness to produce an interaction variable.

Once these variables had been coded, we were left with a data set containing the dependent variable (counts of street robbery in each temporal shift for each day), the proportion of darkness in a shift, temperature, and

an interaction term. This resulted in 2,920 data points for the regression analysis (4 shifts a day for 730 consecutive days).

As we previously argued, temperature and darkness have a strong affiliation. Scholars using both temperature and darkness in models are well advised to adequately account for any issues of multicollinearity (Cohn 1990), as it is difficult to imagine there is no common variance between these variables. Heeding this, our analyses also considered collinearity between the variables. Examination of the matrix of predictors for potential multicollinearity revealed that all variance inflation factors (VIFs) were below 2.3 and thus the common variance was low enough to not pose a problem to the subsequent analyses.

Results

Figure 1 illustrates the monthly variation in robbery across the study areas and both calendar years. When viewed like this, no consistent monthly—and hence, seasonal—trend in street robbery emerges. For London, there appears to be a greater number of offenses in the first two or three months of the year. In Glasgow, this volumetric peak comes a little later, around March. We were unable to test for statistically meaningful trends—through seasonal decomposition—due to there being insufficient data points in the time series data. What is noticeable from this figure is that the time series were on a downward trajectory over the 2 years; between 2002 and 2003, there was a decrease of 13 percent in London and 14 percent in Glasgow.

Two negative binomial regression models are presented in Table 3, the two columns representing results for the two study areas. To enable more straightforward interpretation, the coefficients presented have been transformed into incidence rate ratios. This allows us to estimate the change in the rate at which robbery events occur from each independent variable, when the other variables are held constant in the model. Table 4 displays the results of the incidence-rate ratios (IRRs) for both study areas. From this we see that, for London, an increase of one degree centigrade in temperature would be expected to increase the rate of robberies by a factor of 1.0115—an increase in volume of only 1 percent. An increase of 10 degrees increases the predicted volume by 12 percent. An increase of one unit of darkness on the other hand would be expected to increase the rate of srobberies by a factor of 2.6013. In other words, traversing from full daylight to full darkness increases the predicted volume of robbery by a multiple of 2.6 (a 160 percent increase) when other factors are accounted for. For Glasgow, the temperature IRR is not statistically significant, but the darkness variable
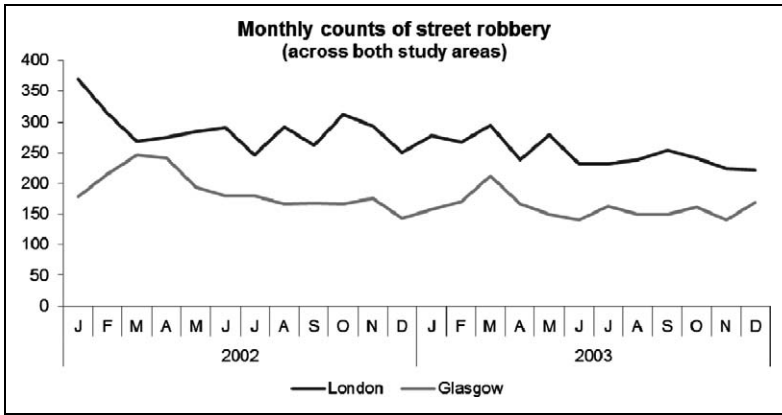
Figure 1. Time series of monthly counts of street robbery for both study areas.

Table 3. Negative Binomial Models for Both Study Areas, with Incidence Rate Ratio (IRR).

	London			Glasgow		
	IRR	Std. Err.	Z Score	IRR	Std. Err.	Z Score
Temperature	1.0115**	.0029	3.94	1.0026**	.0041	0.64
Darkness	2.6013**	.0107	23.11	1.2080**	.0670	3.41
Constant	1.1364**	.0584	2.49	1.2849**	.0795	4.05

Note. The Log Likelihood was −5,310.94 for the London model and −4,684.44 for the Glasgow model.

remains positively associated with the rate of robbery; in that a one unit increase in darkness would be expected to increase the volume of robbery by a factor of 1.21 (a 21 percent increase).

Taken together, these results indicate that the presence of darkness is a key factor when predicting robbery events in both study areas, although this relationship is stronger in London than in Glasgow. Temperature on the other hand was only statistically significant in the London study area, and only had a marginal expected effect on the rate of robbery. However, it remains to examine the effect of the interaction between temperature and darkness. In other words, are the warmer darker periods particularly high in levels of robbery and do cooler, lighter periods experience lower levels? The second set of models set out to answer these questions and can be seen in Table 4 and also report IRRs.

Table 4. Negative Binomial Models for Both Study Areas Using the Interaction Term as the Independent Variable Alongside the Darkness and Temperature Variables.

	London			Glasgow		
	IRR	Std. Err.	Z score	IRR	Std. Err.	Z score
Darkness	2.6683**	.2397	10.92	1.3527**	.1336	3.06
Temperature	1.0127**	.0047	2.73	1.0088**	.0061	1.45
Interaction	0.9978**	.0067	−0.32	.9881**	.0085	−1.39
Constant	1.1184**	.0805	1.55	1.1916**	.0983	2.12

Note. The log likelihood was −5,310.89 for the London model and −4,683.48 for the Glasgow model.

This analysis uses the interaction term as an additional independent variable. The results show that for London, the interaction term is not significant, whereas the darkness and temperature variables remain so. This shows that while a higher volume of robbery is predicted in warmer periods and higher volumes are predicted in darker periods, it is not necessarily the case that the periods that are both warmer and darker will have predicted levels of robbery that are higher still. There are similar results for Glasgow, demonstrating that while darkness remains a significant predictor of higher volumes of robbery, it is not necessarily the case that the time periods that are both mild and dark experience a higher predicted level of robbery over and above this.

Discussion

In this article, we posit that darkness is an important environmental condition and there is good reason to believe that it might facilitate crime. Our research provides the first known direct test of this meteorological variable on seasonal patterns of street robbery, alongside the more omnipresent variable of temperature. The results showed that the environmental condition of darkness was significantly associated with an increase in the expected number of street robberies. This result held over both study areas that have differing levels of darkness throughout the year. This demonstrates that darkness may well be a factor in predicting robberies in differing contexts. Temperature did not fare so well in the models; it was only statistically significant for the London study area and less so than the darkness variable. The coefficient demonstrated fairly modest increases in predicted robbery volumes (1 percent) for each one Celsius increase in temperature.

Additionally, the interaction models showed the consistent significance of darkness but did not reveal any further systematic impact of periods that were both dark and mild on expected levels of street robbery.

These consistent findings for darkness but not temperature can shed some light on the possible mechanisms of street robbery. They suggest that the condition of darkness works particularly well for street robbers. Although it is not directly tested here, it is difficult to argue against the possibility that this is due to the levels of guardianship. To be an effective guardian against crime, you need to not only be present but also be able to act in this capacity (Reynald 2010). Darkness can take away both these aspects—there may well be a lower density of people on the street in these conditions and, for those who are there, it is less likely they will be able to observe any wrongdoing. In addition to the objective level of guardianship, darkness also is likely to affect offender's perceptions of their own anonymity and in turn change their behavior. The finding that burglary offenders often have alternative strategies in the darkness and the daylight supports this possibility (Coupe and Blake 2006).

Further implications of the findings are first, that it is important to disaggregate data into sensible temporal categories to have a real understanding of the relationship between the variables under scrutiny. If this had not been done, and analysis was performed solely on whole days (with their respective daily average temperature and daylight hours), then the true relationships might have been masked.

Second, the findings indicate that darkness is an important factor that has implications for policy. If its influence holds across different locales and data, then this is useful information for police resource planning. For example, detection and disruption activities can be sensibly aligned to times of darkness, which differ throughout the year. Other long-term crime prevention strategies (such as improving street lighting) can be considered as a way of inhibiting street robbery at nighttime.

This study suffers from some methodological limitations; chiefly due to measurement issues with the variables used. Using police-recorded violent crime data is likely to be only one portion of all violence that actually occurred (Shepherd 2001), and this may accentuate or temper any empirical findings. Relatedly, we cannot be certain that the fluctuations seen in the counts of robberies were not influenced by police activity, which will also fluctuate over time. We also acknowledge that our study areas are relatively large and, as such, do not account for locally geographic variations in volumes of robbery or police activity. We recognize that seasonal patterns of crime are likely to vary at the neighborhood level and intend to account for this in future research.

This research followed in the long history of researchers to aggregate imprecise weather data in order to derive meaningful empirical results (Cohn 1993; Heller and Markland 1970; Lab and Hirschel 1988; Van Koppen and Jansen 1999). We fully acknowledge that the temperature values we assigned to each shift will be imperfect measures of the precise temperature at the time of offense and that this will compromise the robustness of the results. In addition, this research approximated the effect of darkness by calculating the proportion of time after sunset in each temporal shift. It did not account for any residual light, whether that was natural (e.g., the luminosity of the moon) or artificial (street lighting). We did not consider levels of humidity in this analysis—they do not vary to a great degree either over time or over geographical location in the United Kingdom—they could however be of more significance elsewhere.

Finally, the research could not systematically measure target density in the study areas. Target presence is a prerequisite of street robbery, and target density has often been theorized as being important to the risk of robbery occurring (Monk, Heinonen and Eck 2010) and ideally should be accounted for in any modeling strategies. Critically though, data availability on ambient populations (i.e., people on the street) are rarely available at different times of the day and year and were not for our study areas.

We argue in this article that darkness is a crucial inhibitor of guardianship, as defined within the tenets of the routine activity approach. Alternative mechanisms driving the correlation of darkness and street robbery may be due to the offender's motivation (i.e., lifestyle or biological processes) or the suitability of targets (i.e., the offender feeds off people with cash on their person or inebriated in hours of darkness, or interaction with illegal drugs markets). It is also interesting to note that the effects of darkness (and in fact temperature) were more pronounced in London than in Glasgow. One reason for this might be variation in the comfort of the external conditions. Table 1 demonstrates that the temperatures can become very cold at times in Glasgow and that it is more likely to rain in this area. Perhaps on occasion, more extreme conditions limit the number of suitable targets and offenders on the street, rendering the level of guardianship and darkness less relevant. Further temporally sensitive independent variables could therefore assist in producing more powerful models of variation in crime by time of the day and across the seasons and could usefully be the subject of future research. Studies could also further address differences in the effects at different points on the temperature scale—for example a one-degree increase on a really hot summer day may have more of an influence on the robbery rate than it does on a moderate day.

Declaration of Conflicting Interests

Funding

Notes

1. Some scholars have traced this back to Aristotle's musings on the relationship between thermic seasons and suicide. Others have credited Hippocrates with writing about criminal seasonality (Brearley 1932 as cited by Block 1984).
2. These authors also tested whether commercial robberies were more likely in the run up to Christmas and Sinterklaas (November and December) but found a lack of evidence to support this hypothesis.
3. The London data set had 53 records removed, and the Glasgow data set had 39 records removed based on this criteria.
4. Using the ''countfit'' command in the statistical package Stata.
5. These data were obtained from http://www.timeanddate.com/.
6. www.wunderground.com.
7. These were London City Airport (LCY) and Glasgow (EGPF).

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