Temper and Temperature on the Diamond: The Heat-Aggression Relationship in Major League Baseball

Alan S. Reifman
Richard P. Larrick
Steven Fein
University of Michigan

Archival data from major league baseball games played during the 1986, 1987, and 1988 seasons (total N *= 826 games) were used to assess the association between the temperatures at the games and the number of batters hit by a pitch during them. A positive and significant relationship was found between temperature and the number of hit batters per game, even when potentially confounding variables having nothing to do with aggression were partialed out. A similar relationship was found for games played during the 1962 season. The shape of this relationship appears to be linear, suggesting that higher temperatures lead major league pitchers to become more aggressive in pitching to batters.*

Mark Twain, among others, observed that everybody talks about the weather. One aspect of weather that people have talked about for centuries is its effects on human behavior. Probably the most discussed idea regarding the effects of weather on people's behavior is the idea that very hot weather is associated with aggression and violence. This idea has been expressed many times, from the classic works of the theater, such as Shakespeare's *Romeo and Juliet,* to contemporary film, such as Spike Lee's *Do the Right Thing.* Indeed, the metaphors of anger and aggression, such as "hot under the collar," "steamed," and "blood boiling," are replete with imagery of heat.

This long-standing idea that heat and aggression are related has recently inspired a growing body of research that aims to test this hypothesis scientifically and to determine how and why they are related. During the last 2 decades numerous studies—both correlational and experimental—have found that aggressive behavior increases as a function of increasing ambient temperatures (for a review, see Anderson, 1989). Although the basic heat-aggression relationship appears well established, research on this problem continues today on several fronts. One important issue concerns the range of domains to which the relationship can be extended. Anderson (1987) has stated that only through the cumulation of results using different operationalizations and different social contexts can the authenticity of a heat-aggression relationship be confirmed. Thus far, however, most of the field/archival studies on this topic have examined crime statistics as the measure of aggression (e.g., Anderson, 1987), although other domains have begun to be explored, such as horn honking among drivers (Baron, 1976; Kenrick & MacFarlane, 1984). One domain in which the heat-aggression relationship has not been investigated is that of sports. This is an important domain because much of our leisure time is spent participating in or watching others engage in sports and, depending on the nature of the sport, there is often the opportunity for aggression and even violence to manifest itself during the course of a game. An examination of the heat-aggression relationship in sports would be valuable both because of the ubiquity of sports in our culture and because the measures of aggression therein would not be associated with extraneous factors (e.g., socioeconomic variables, number of people outdoors) that plague much of the archival research, nor would they be as trivial as some of the measures of aggression used in field and

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laboratory research. The present authors were especially interested in examining the heat-aggression relationship in the sport of baseball. Baseball offers the advantages of typically being played outdoors and in the summertime. Furthermore, it is a game in which much of what occurs on the field is easily quantified. Indeed, major league baseball fans are notorious for their love of baseball statistics.

A second issue with which research on heat and aggression is concerned is how heat and aggression are related. Specifically, what is the shape of the relation? Several shapes have been suggested, including a straight linear function, a J-shaped function, an inverted-U-shaped function, and an M-shaped function (Anderson, 1989). Because major league baseball is played from midspring to midfall, games are played in a great variety of temperatures. Although games are rarely played in uncomfortably cold temperatures, they are played in temperatures that are as hot as the weather ever gets in most places in the United States and Canada. Therefore, data from major league baseball games offer a good naturalistic test of some of the theories concerning the shape of the heat-aggression relationship.

Although we are aware of no previous research that has investigated the issue of heat and aggression in sports, some research has been conducted on other variables affecting aggression in sports. For example, Frank and Gilovich (1988) found that professional football and ice hockey teams with black uniforms received more penalties over a period of several years than teams with nonblack uniforms. It may be interesting to note that Dick Butkus, one of professional football's most aggressive linebackers of all time, responded to this finding by saying, "All I know was that we wore dark in the hot weather, dark colors attract heat, and it was uncomfortable" (Boxer, 1989, p. 56).

In the present study aggression was operationalized as the number of times major league baseball pitchers hit batters with pitched balls. In recent years, batters being hit by pitches has been a serious and highly publicized problem in baseball. Baseball players and analysts have suggested numerous causes, such as pitchers' frustration and need to intimidate hitters (Hersch, 1987; Lopresti, 1987). A goal of the present research was to determine whether heat, independent of these other factors, may be a significant factor that has been largely overlooked by the baseball community. Specifically, using the individual baseball game as the unit of analysis, we examined whether the number of hit batters was related to ambient temperature in a large sample of major league games.

Because factors other than ambient temperature might contribute to the rate of batters being hit by pitches, the most plausible of these were incorporated into the analyses as control variables. Partly on the basis of the speculations of baseball players and experts about the causes of batters being hit by pitches (e.g., Hersch, 1987; Lopresti, 1987), the following potential predictors of the number of batters hit by pitches during a game were recorded for each game: the total number of walks, the total number of wild pitches, the total number of passed balls, the total number of errors, the total number of home runs, and the attendance. The number of walks and wild pitches in a game may serve as an index of pitcher inaccuracy or wildness and thus may correlate with the number of batters hit by pitches.[1] Errors are a measure of inaccuracy or wildness displayed by all the players on the team in fielding and throwing. Passed balls may serve as an index either of pitcher wildness or of inaccuracy displayed by the catcher (see Note 1). Home runs are likely to covary with the number of batters hit by a pitch in a game for two reasons that have frequently been cited by baseball analysts. One is that allowing home runs is a source of frustration for pitchers and they may vent their frustrations by hitting batters. A second reason is strategic. After allowing a home run, pitchers need to reclaim their authority on the mound by intimidating the hitters and preventing them from taking their best swings. Finally, attendance was used as an index of the importance or intensity of a game. It was thought that the more important a game, the more aggressively it would be played, perhaps leading to an increased number of hit batters. Because temperature and perceived importance of a game are likely to covary (games played in August have both higher temperatures and higher perceived importance than games played in April), this control variable is particularly important.

Concerning the shape of the heat-aggression relationship, the existing literature would suggest a priori hypotheses of both linearity and curvilinearity. The latter would arise if aggression increased with temperature up to a point but then declined owing to debilitation or to the opportunity to escape the hot environment rather than aggressing. Other curvilinear functions besides this inverted-U might also be possible (for a discussion of these issues, see Anderson, 1989).

METHOD

Microfilm issues of major daily newspapers were consulted to obtain data on weather and major league baseball games. Random samples of games were taken from three major league baseball seasons: 1986, 1987, and 1988. The 1986 sample included every 10th game played during the season (n = 215 games). Every 7th game during the season was included for the 1987 (n = 304) and 1988 (n = 307) samples.[2] For each game sampled,

TABLE 1: Regression Results for Number of Players Hit by a Pitch (HBP) Regressed on Temperature, Walks, Wild Pitches, Passed Balls, Errors, Home Runs, and Attendance

Predictor	b	*Standard Error*	*Beta*
Temperature	.007***	.002175	.11
Walks	.018**	.007489	.09
Wild pitches	.050*	.027235	.06
Passed balls	.033	.049953	.02
Errors	–.018	.016730	–.04
Home runs	.011	.014593	.02
Attendance	.000	.000002	.03
Constant	–.309*	.175426	
R^2		.03	
Adjusted R^2		.02	
F		3.53***	
N		826	

*$p < .10$; **$p < .05$; ***$p < .01$, two-tailed.

TABLE 2: Correlations of Temperature and Number of Players Hit by a Pitch (HBP) With Measures of Wildness

	HBPs	*Walks*	*Wild Pitches*	*Passed Balls*	*Errors*
Temperature	.11***	–.06*	–.05	–.06*	.02
HBP		.09***	.08**	.03	–.03

*$p < .10$; **$p < .05$; ***$p < .01$, two-tailed

the number of players hit by a pitch (HBP) was recorded. Within the same newspaper issue, the high temperature (°F) in the home city the day of the game was also recorded.[3] The numbers of walks, wild pitches, passed balls, errors, home runs, and fans in attendance in each game were recorded as control variables.

RESULTS

To test the primary prediction that the number of HBPs in a game increases with temperature, a Pearson product-moment correlation between temperature and HBPs was calculated for all the games in our sample from the 1986, 1987, and 1988 seasons. As predicted, this correlation was positive and significant, $r(824) = .11$, $p < .002$ (all tests of significance are two-tailed unless otherwise noted). To determine whether this relationship would be maintained with the potentially confounding variables described above controlled for, we regressed HBP on temperature, walks, wild pitches, passed balls, errors, home runs, and attendance. The standardized and unstandardized regression coefficients from this multiple regression are reported in Table 1. Because the particular seasons in which games were played neither interested us theoretically nor produced any statistically significant effects (when dummy variables representing the seasons were omitted from regression analysis, the amount of variance explained was not reduced significantly, $\Delta R^2 = .002$, $F[2, 816] = 1.03$, n.s.), the regression analyses reported here were performed on data collapsed across the three seasons. Supporting our prediction, temperature was positively and significantly related to HBP ($\beta = .11$, $b = .007$, $p < .002$) when the alternative variables were partialed out.

The results of the multiple regression indicate that the temperature-HBP relationship is not mediated by pitcher wildness (as measured by walks, wild pitches, and passed balls). An additional way of understanding this point is to examine the correlations between the measures of pitcher wildness and HBP and between pitcher wildness and temperature. If temperature produces wildness (e.g., resulting from fatigue or a pitcher's slippery hand), and if wildness mediates the temperatures-HBP relationship, then one would expect that (a) temperature would be positively correlated with pitcher wildness and (b) pitcher wildness would be positively correlated with HBP. As can be seen in Table 2, however, temperature is *negatively* correlated with the measures of wildness. Thus, heat does not lead to greater pitcher wildness, and the alternative explanation that wildness mediates the temperature-HBP relationship is rendered less plausible.

Although it is clear from the regression analysis and from the negative relationship between temperature and the measures of wildness that pitcher wildness is not a significant mediating factor in the relationship between temperature and HBP, these analyses do not address the question whether the measures of wildness taken as a whole are significantly related to HBP, independent of temperature. To examine this issue, a multiple regression analysis was performed, identical to the first with the exception that the three measures of pitcher wildness were removed from the equation. Removing these measures significantly reduced the amount of variance accounted for by the regression $\Delta R^2 = .0144$, $F(3, 818) = 4.05$, $p < .01$, indicating that wildness is related to HBP independent of temperature.

Somewhat surprisingly, the number of errors committed per game, which is a measure of general inaccuracy and wildness by fielders, was negatively and not significantly related to HBP in the regression analysis. Finally, neither home runs nor attendance was significantly related to HBP.

The Temperature-HBP Relationship in Each of the Home Parks

Although the analyses reported above discredit several potentially trivializing mediators of the temperature-

HBP relationship, a final alternative explanation that must be ruled out is that this relationship was produced spuriously by incidental differences in the tendency to throw HBPs among the various teams. This alternative explanation arises in part because the 26 home parks of the teams are located in regions that vary greatly in climate. It is possible that the relationship reported between temperature and HBPs could be due simply to the fact that the teams that throw the most HBPs just happen to play in warmer climates and the teams that throw the fewest happen to play in the colder climates, for reasons that have nothing to do with temperature. For example, suppose the Texas Rangers are particularly prone to throwing HBPs, independent of temperature. If this were the case, then a relatively large constant would be added to the total number of HBPs thrown in their home park. Because their home park is located in a warm climate, this could increase the overall relationship between HBPs and temperature even if Texas pitchers are no more likely to throw HBPs at home when it is hot than when it is cold there. In fact, if this were true for a number of teams, and if the opposite were true of teams that play in colder climates, we could obtain a positive overall correlation collapsed across home parks even if there were no relationship between temperature and HBPs at any particular home park. However, if the overall relationship between temperature and HBPs is valid, then we would expect to find correlations at the individual home parks that are similar to the overall correlation between temperature and HBPs.

To examine this issue, we calculated Pearson product-moment correlations between total number of HBPs and temperature for all the games played at each of the 23 home parks that are not domed. Most of these within-park correlations were positive (16 of the 23 teams), and the average of these correlations was .11 (SD = .196), which was significantly different from zero in a one-sample t test, $t(22) = 2.69$, $p < .02$, two-tailed. Because this average is similar to the correlation found between temperature and HBPs when collapsing across home parks (r = .11), these results support the claim that this relationship was not produced spuriously by incidental differences among the various teams.

As an additional test of the alternative explanation that the overall relationship found between temperature and HBPs may have been produced by a few teams that tend to throw either a large or a small number of HBPs, we conducted a one-way analysis of variance of the mean numbers of HBPs for games played at each home park. Further discrediting this alternative account, the ANOVA revealed no significant main effect for home park, $F(25, 800) = 1.14$, n.s. Moreover, using the Tukey-Kramer HSD procedure (Kirk, 1982) to test for differences between all pairs of means revealed that none of the differences was statistically significant. These results indicate that batters were not significantly more likely to be hit in one home park than in another.

TABLE 3: Correlations Between Temperature and Number of Players Hit by a Pitch (HBP) for Individual Seasons

	1986	*1987*	*1988*	*1962*
Correlations between temperature and HBP (n)	.11 (215)	.09 (304)	.11 (307)	.10 (228)

Replication of the Relationship in the 1962 Season

The analyses reported thus far concern data from games played during the 1986, 1987, and 1988 seasons. We also collected temperature and HBP data for the 1962 season, using the same sampling procedure as was used for the 1987 and 1988 seasons. We collected these additional data for two reasons. First, this would allow us to examine the generalizability of the temperature-HBP relationship across different periods of time. Second, by looking at a season in which the personnel and the personalities of the teams, and even several of the teams themselves, were very different than among the 26 teams in the 1986-1988 seasons, this would provide an additional test of the alternative explanation that the relationship we found was produced by incidental differences among the pitchers who pitched for the 26 teams between 1986 and 1988.

The Pearson product-moment correlation between temperature and HBP for the 1962 games was positive and marginally significant, $r(226) = .10$, $p < .07$, one-tailed. As can be seen in Table 3, the correlation for the 1962 season was similar in magnitude to the correlations found for the 1986, 1987, and 1988 seasons. The consistency of these correlations supports the generalizability of the relationship between temperature and HBP. In addition, it further reduces the plausibility of the idea that incidental differences among the pitchers on the 26 teams during 1986-1988 could have produced the temperature-HBP relationship found for those seasons.

The Shape of the Temperature-HBP Relationship

One of the issues that has been important in the heat-aggression literature is the shape of the function that relates heat to aggression. In order for the reader to examine the shape of the relationship between temperature and HBP, we have displayed in Figure 1 the mean numbers of HBPs in games from our 1986-1988 sample that were played at four levels of temperature.

The shape of the relationship between temperature and HBP was analyzed by applying a set of orthogonal polynomial contrasts to the average number of HBPs in

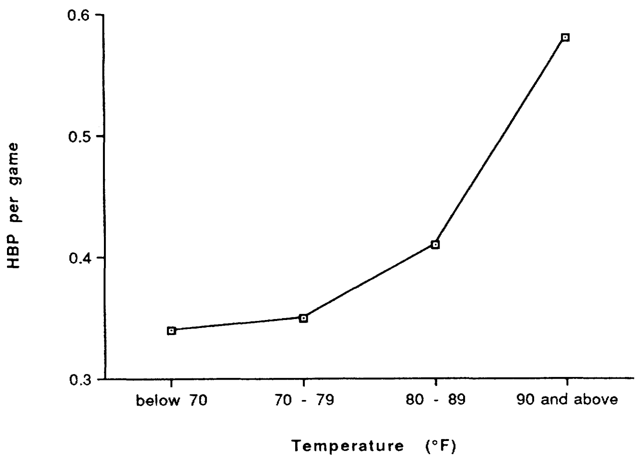

Figure 1 Mean number of players hit by a pitch (HBPs) in games played below 70 °F (n = 176), between 70 °F and 79 °F (n = 315), between 80 °F and 89 °F (n = 224), and at 90 °F and above (n = 111).

games played at the four levels of temperature. The polynomial contrasts tested for linear, quadratic, and cubic trends in the means (Hays, 1981, Table VII). A one-way ANOVA verified that the number of HBPs was significantly different across the levels of temperature, $F(3, 822) = 4.01$, $p < .008$. The polynomial contrasts indicated that the linear contrast was significant, $F(1, 822) = 10.60$, $p < .001$; the quadratic contrast was not significant but suggested a potential trend for a J-shaped function, $F(1, 822) = 1.58$, $p < .15$; and the cubic contrast did not approach significance, $F < 1.00$. These results are most consistent with a linear, rather than a curvilinear, relationship between temperature and HBP.

DISCUSSION

The results of the present study revealed that mean hit-by-pitch levels rose linearly with temperature. Regression analyses revealed that this relationship remained positive and significant when several variables that have nothing to do with aggression but could plausibly mediate a temperature-HBP relationship were partialed out. Indeed, because the measures of pitcher wildness and inaccuracy were negatively correlated with temperature, the measures of pitcher wildness apparently suppressed, rather than confounded, the temperature-HBP relationship.

Moreover, the results of a series of correlations between temperature and HBPs calculated for each of the nondomed home stadiums and of an analysis looking for significant differences among the mean numbers of HBPs thrown at the various home parks suggest that the observed temperature-HBP relationship was not produced spuriously by incidental differences among the teams. The average of the within-park correlations between temperature and HBPs was identical to the correlation between temperature and HBPs when collapsed across home parks, and the average number of HBPs did not vary significantly as a function of home park. Further discrediting this alternative explanation was the finding of a similar temperature-HBP relationship in the 1962 season, a season featuring none of the players—and not all of the teams—who were included in the 1986-1988 samples. Though not reported in the Results section, one final piece of evidence arguing against the alternative explanation is that only 50% of the pitchers who pitched in the major leagues for all three seasons, 1986-1988, played for the same team throughout (MacLean, 1989). Indeed, this figure underestimates the turnover rate because it does not take into account the rookies who entered and the players who retired from the leagues at various points during the three seasons.

This study provides further evidence for the existence of a relationship between heat and aggression, and it extends our knowledge of this relationship to the domain of sports. In addition, the results of this study lend some support to the idea that the shape of the heat-aggression relationship is linear. Of course, no major league baseball games are played in extremely cold temperatures, and few are played in temperatures that exceed 100°F. Therefore, the data from our study cannot allow us to rule out the possibility that heat and aggression are related in a nonlinear fashion at temperatures more extreme than in our range. It should be noted, however, that our sample does accurately represent the range of temperatures present in the summer months in most of the United States and southern Canada.

Heat-aggression effects have usually been explained in terms of the major theories of aggression, such as excitation-transfer/misattribution and cognitive neoassociation (for this type of discussion, see Anderson, 1989). A recently proposed theory of emotion also offers an interesting insight into the possible mechanisms underlying the heat-aggression relationship. In their vascular theory of emotional efference, Zajonc, Murphy, and Inglehart (1989) suggest that brain temperature—which is partially regulated by a venous structure in the nose—and temperature-related neurochemistry may underlie heat-aggression effects. Proposed mechanisms such as these are clearly far away from our level of data collection. They do, however, represent useful hypotheses about the nature of the relationship of temperature to negative affect and aggression, as well as suggest possible interventions to reduce aggression in naturalistic settings such as sports.

In addition to their theoretical implications, the results have practical significance. Although the magnitude of the correlation is rather small, the slope of the temperature-HBP function is fairly steep in the higher temperatures. In fact, there is approximately a two-thirds greater chance of a batter's being hit in a game played when the temperature is in the nineties or above than in a game played when the temperature is in the seventies or below. Considering that during the course of one full baseball season 2,106 major league baseball games are played, numerous batters will suffer the consequences of the relationship between heat and aggression. Given the potential for serious injury whenever a batter gets hit with a pitch traveling approximately 90 miles per hour, any statistical relationship found between heat and batters' being hit must be regarded as noteworthy.

These results suggest that the current trends in major league baseball of a greater number of night games and a greater number of domed stadiums, trends that have aroused the ire of many a baseball purist, may prove to decrease the number of batters being hit by pitches, and such a decrease could save some careers or even lives. Although the authors do not call for the abolishment of summer day games in nondomed stadiums, we do suggest that baseball players should take care to keep cool during games played in hot weather. Indeed, the many nonprofessional athletes who flock to the recreational fields and courts as the weather gets warm every spring and summer should also be careful of rising temperatures and tempers. It may be that talking about the weather, and specifically about what effects it can have on human behavior, can save many from pain and remorse.

NOTES

1. Wild pitches and passed balls are recorded only when at least one runner advances a base, however, rendering them a less-than-perfect measure of pitcher inaccuracy.

2. Each author recorded the data for a third of each season. For the first day of his third of the 1986 season, each author selected randomly one box score listed in the *Los Angeles Times*, recorded the data from it, and from then on recorded the data from every tenth box score listed. When the data from a particular box score were recorded and fewer than 10 games remained in that day's list of box scores, the remaining games were counted, and that number was carried to the beginning of the next day until a 10th game was listed. Because the number of games played on a particular day ranged from 1 to 13, and because the games are listed in a relatively haphazard order in the newspaper, this procedure allowed us to sample approximately equal numbers of games from all the teams. The same procedure was used to sample every 7th game for the other seasons reported in this article.

3. The three teams that played their home games in air-conditioned domed stadiums during the 1986-1988 seasons—the Houston Astros, Minnesota Twins, and Seattle Mariners—were contacted, and they provided us with the standard ambient temperatures at which their home games are played.

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