A relationship between temperature and aggression in NFL football penalties

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Abstract

Background: Increased ambient temperature has been implicated in increased physical aggression, which has important practical consequences. The present study investigates this established relationship between aggressive behavior and ambient temperature in the highly aggressive context of professional football in the National Football League (NFL).

Methods: Using a publicly available dataset, authors conducted multiple hierarchical regression analyses on game-level data (2326 games).

Results: The analysis revealed that temperature positively predicted aggressive penalties in football, and that this relationship was significant for teams playing at home but not for visiting teams.

Conclusion: These results indicate that even in the aggressive context of football, warmer weather contributes to increased violence. Further, the presence of the heat-aggression relationship for the home team suggests that the characteristics of interacting groups may influence whether heat would have an adverse effect on the outcome of those interactions.

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1. Introduction

Weather is an environmental characteristic that influences affect and cognition. In fact, researchers have shown that ambient temperature is the primary factor in this relationship.1 The experience of warm spring weather is associated with increased positive affect and broadened cognition, while hotter summer weather is associated with decreased positive affect and frustration and winter weather associated with more depressive symptoms. A consequence of decreased positive affect in hot weather is an increase in aggressive acts of violence.2–4 Anderson and colleagues5 investigated rates of violent crime and property crime in the US over a 45-year period and demonstrated more violent assaults with temperature increases, after controlling for population and age.

Several models have been explored in the literature to explain the relationship between temperature and aggression. The predominant model is General Aggression Model,5–7 which suggests there are combinations of inputs that impact the internal states of the individual (e.g., anger), such as environmental/situational factors and personal tendencies (e.g., poor self-control). These inputs then influence decision making processes that determine whether a behavioral outcome is aggressive. In this model, ambient temperature is an environmental input biasing both affect (e.g., irritation) and mental schemas toward aggression.

The importance of the heat-aggression relationship becomes more concerning, given the recognition of climate change and the possible impact of increased average global temperature on...
human interaction, with growing evidence linking warmer temperatures to intergroup conflict frequency. Also, given the continued growth of the human population and the known relationship between population growth, conflict, and warfare, an understanding of the characteristics such as heat that affect the nature of human violence is essential. An overview of potential effects of increasing global temperature on human society reveals several broad categories of negative consequence, including but not limited to increasing civil unrest, higher individual irritation, and an increasing tendency to perceive aggression in others.

Given the concern of increased intergroup conflict due to population increase and increased global temperatures, heat and aggression would be important to study in an intergroup context. Previous research on intergroup emotions and aggression have found that the primary predictor between individual endorsement of offensive actions towards outgroups is the perceived strength of the ingroup (e.g., size), although this relationship is mediated by reported experience of anger. The rationale for this relationship is unclear, but it may be due to a rapid calculation that intergroup competition between members of social species makes necessary. As an example of this, ingroup chimpanzees are significantly more likely to act aggressive toward an outgroup intruder when the ingroup has the numerical advantage. Given that heat contributes to negative affective states such as anger, which mediates the ingroup strength and offensive action relationship, one could anticipate that the heat-aggression relationship is more pronounced for contexts where one group has more perceived support than the other group.

Researchers have extended the investigation of temperature and aggression to team sports, as they provided a unique and well-defined natural experiment. Highly competitive games involve precarious social relationships; therefore, ambient temperature is likely to influence behavioral outcomes during games. In baseball, as temperature increases, so does the number of batters struck by a pitch. Reifman et al. suggested that rising temperatures result in aggressive tendencies in players, leading to intentional aggressive throws by pitchers. Further research in baseball demonstrated that in even hotter conditions, if teammates have been struck by the opposing team’s pitcher, pitchers are more likely to retaliate by hitting the batter with the ball, particularly with increasing number of teammates struck.

The National Football League (NFL) football season is ideal for examining the heat-aggression phenomenon, as football is played in the colder fall, winter, and spring seasons, allowing for a wide range of available temperatures to explore the heat-aggression relationship. The variability in location is also important as weather turns cool in northern states earlier and temperatures are elevated longer in southern states.

More importantly, NFL football is a contact sport, which may be considered especially aggressive, as evidenced by the increased risk of traumatic brain injury and cognitive dysfunction following participation. Therefore, examining data from football games allows consideration and analysis of the effect of ambient temperature on aggression in a heightened aggression setting, and allows investigation of whether high ambient temperature retains its influence to increase aggressive acts. Though football may be considered aggressive in general, combative penalties (e.g., unnecessary roughness) can distinguish between hostile (or affective) aggression, which may be sensitive to temperature, and instrumental or purposeful aggression.

The context of football allows for an investigation into the relationship between heat, physical aggression, and intergroup dynamics. Given the aforementioned findings on increased ingroup support contributing to aggressive action, football teams playing at home (high ingroup support) are more likely to commit acts of aggression against the opposing team, particularly under conditions of high ambient temperature as heat contributes to negative affective states such as anger. Furthermore, heat is more likely to contribute to aggression by influencing the internal state of home team players, who are more apt to experience territoriality and pressure because they perform on their own turf and before the home crowd. The present study investigates the issue by using football as the context to first verify whether the heat-aggression relationship exists, and then determine whether the relationship holds true for both home teams and away teams.

There is also some debate on whether the relationship between temperature and aggression is linear or non-linear. There is some evidence that the relationship is curvilinear when the ability to escape both heat and social contact is taken into account. However, re-analyses of these data have primarily found a linear relationship, particularly during periods of high violence risk, which suggests that in the high physical context of NFL football a linear relationship should be present between temperature and aggressive penalties.

The finding of increased aggression in higher temperatures would have significant implications for other aggression contexts where the ambient temperature varies. These contexts can include other aggressive sports such as rugby, but of more concern are those situations where lives are at stake, such as mass protests and warfare. Therefore, we predict that a significant linear relationship between temperature and aggressive penalties will be found, despite the already aggressive context of the sport, and that this relationship will hold true for home teams but not visiting teams due to the perceived ingroup support of home teams.

2. Methods

To explore the temperature and aggression relationship in football, the authors obtained publicly available, secondary data from the website Armchair Analysis. It contained game-level data for all games in the NFL seasons 2000–2011. Variables included but were not limited to information on game-day temperature, points by home team and away team, number and type of penalties. Each game functioned as an independent unit of analysis, generating data for the variables of interest.
Two thousand three-hundred and twenty-six games included all required measures and were analyzed after excluding one game as an outlier due to an excessive number of penalties. The descriptive statistics are presented in Table 1. The average temperature per game was 58.27°F, ranging from −1°F to 109°F. As the temperature information is particularly important, mean temperature was 59.01 (SD = 16.43) with a median of 61, temperature skewness was −0.390 (SD = 0.046), and kurtosis was −0.163 (SD = 0.093). The 10th percentile was 36, 25th percentile was 48, 50th percentile was 61, 75th percentile was 70, and 90th percentile was 80. Considering the games with temperature data, 173 of them were below freezing and 97 above 85°F. Humidity was included as a control variable, because high humidity is uncomfortable and discomfort is thought to be related to negative affect. The humidity considered here is relative humidity, the percentage of water vapor (partial pressure/saturated pressure) present at a given temperature. Average point spread between teams was included as a control variable. Scores from the home and visiting teams were aggregated to provide a total points score for each game. Penalties such as taunting, face masks, unnecessary roughness, and unsportsmanlike conduct were coded as aggressive. All other penalties were coded as non-aggressive. Besides total non-aggressive and total aggressive penalties, aggressive penalty counts were measured separately for both the home teams and the away teams. In order to verify whether team level tendencies would significantly affect the following analyses, a simple ANOVA found that there was a significant effect of teams on visitor aggressive penalties (F(31, 3155) = 2.141, p < 0.001) and on home aggressive penalties (F(31, 3155) = 2.044, p = 0.001). However, including temperature as a covariate, the interaction between team and temperature is not significant for visitors (F(31, 2723) = 873, p = 0.668) or home (F(31, 2723) = 0.907, p = 0.583). This implies that temperature effects do not interact with specific team predilections. Other potential control variables such as the southern culture of honor were excluded from the analysis as substantive prior research has found that particular variable confounded with temperature, as the southern regions of the US tend to be hotter than other regions.

3. Results

Multiple simultaneous regression analyses were performed to determine if temperature predicted the amount of aggressive penalties (1) overall, (2) for the home team, and (3) for the visiting team. Corresponding logistic regressions were also performed alongside the standard ordinary least squares regression analyses, and while not reported here, the results were highly similar. The correlation matrix is presented in Table 2. The results indicate that for overall aggressive penalties, non-aggressive penalties and total game points accounted for a significant amount of the variance (∑ = 0.037, F(5, 2320) = 17.877, p < 0.001). Total game points, non-aggressive (technical) penalties, and ambient temperature were all significantly associated with more aggressive penalties, but point spread and humidity were not (Table 3). Controlling for the other variables, temperature significantly predicted aggressive penalties (∑ = 0.055, p = 0.008). A follow-up analysis also found that temperature significantly predicts non-aggressive penalties for visitors (∑ = 0.120, p = 0.001), and on home aggressive penalties (∑ = 0.120, p = 0.001). However, including temperature as a covariate, the interaction between team and temperature is not significant for visitors (F(31, 2723) = 873, p = 0.668) or home (F(31, 2723) = 0.907, p = 0.583). This implies that temperature effects do not interact with specific team predilections. Other potential control variables such as the southern culture of honor were excluded from the analysis as substantive prior research has found that particular variable confounded with temperature, as the southern regions of the US tend to be hotter than other regions.

Table 1
Descriptive statistics of the analyzed game level data (n = 2326).

| Measure                  | Min | Max | Mean | SD  |
|--------------------------|-----|-----|------|-----|
| Temperature (°F)         | −1  | 109 | 58.27 | 16.96 |
| Humidity (%)             | 0   | 100 | 58.79 | 20.01 |
| Game points              | 3   | 106 | 41.89 | 14.21 |
| Point spread             | 0   | 24  | 5.373 | 3.396 |
| Aggressive penalties     | 0   | 9   | 2.074 | 1.629 |
| Aggressive penalties for visiting team | 0 | 6 | 1.045 | 1.076 |
| Aggressive penalties for home team | 0 | 6 | 1.030 | 1.058 |
| Non-aggressive penalties | 2   | 32  | 12.178 | 4.308 |
| Non-aggressive penalties for visiting team | 0 | 20 | 6.319 | 2.933 |
| Non-aggressive penalties for home team | 0 | 18 | 5.859 | 2.729 |

Table 2
Correlation matrix of the analyzed game level variables (n = 2326).

| Measure                  | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  |
|--------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1. Temperature           | −   | −0.131** | −   | −0.017 | −0.091** | −0.015 | 0.071** | −0.094 | 0.035 | 0.074** |
| 2. Humidity              | −0.131** | −     | −0.001 | −0.017 | −0.091** | −0.031 | 0.001 | −0.012 | 0.056** | 0.004 |
| 3. Game points           | −0.017 | 0.000 | −     | −0.091** | −0.031 | 0.001 | −0.012 | 0.082** | −0.004 | 0.004 |
| 4. Point spread          | −0.017 | −0.001 | −0.091** | −     | −0.015 | 0.069** | 0.099** | 0.027 | −0.038 | 0.010 |
| 5. Aggressive penalties  | 0.071** | −0.012 | 0.082** | 0.099** | −     | −0.026 | 0.768** | 0.014 | 0.123** | 0.094** |
| 6. Aggressive penalties for visiting team | 0.035 | −0.004 | 0.056** | 0.096** | −0.026 | −     | 0.768** | 0.027 | 0.123** | 0.094** |
| 7. Aggressive penalties for home team | 0.074** | −0.015 | 0.069** | 0.096** | 0.099** | 0.014 | −     | 0.166** | 0.094** | 0.014 |
| 8. Non-aggressive penalties | 0.099** | −0.019 | 0.027 | −0.038 | 0.014 | −0.027 | 0.123** | −     | 0.120** | 0.094** |
| 9. Non-aggressive penalties for visiting team | 0.061** | −0.014 | 0.010 | −0.027 | 0.014 | 0.027 | 0.123** | 0.014 | −     | 0.120** |
| 10. Non-aggressive penalties for home team | 0.091** | −0.015 | 0.032 | −0.030 | 0.130** | 0.014 | 0.027 | 0.123** | 0.014 | 0.120** |

**p < 0.01.
penalties ($\beta = 0.158, p < 0.001$), when controlling for total game points, point spread, and humidity.

Total game points, non-aggressive penalties, visitor aggressive penalties, and ambient temperature were all significantly associated with more home aggressive penalties, but point spread and humidity were not (Table 4). Controlling for the other variables, temperature significantly predicted home aggressive penalties ($\beta = 0.060, p = 0.004$).

Total game points, non-aggressive penalties, and home aggressive penalties were all significantly associated with more visitor aggressive penalties, but point spread, humidity, and temperature were not (Table 5). Controlling for the other variables, temperature did not significantly predict visitor aggressive penalties ($\beta = 0.013, p = 0.546$). Given that a heat effect was found for home aggressive penalties and not for visitor aggressive penalties, a repeated measures ANOVA was conducted with aggressive penalties as the dependent variable, team (visitor vs. home) as the repeated measures factor, and temperature, total points, point spread, humidity, and non-aggressive penalties as covariates. However, there was no significant interaction between temperature and the team repeated measures factor ($F(1, 2320) = 2.194, p = 0.193$).

Visitor team aggressive penalties correlates with home team aggressive penalties ($r(2324) = 0.165, p < 0.001$). To determine if temperature influences reciprocal aggression or retaliatory behavior in football as it does in baseball,4 2 regressions were conducted. Controlling for total game points, point spread, non-aggressive penalties, humidity, home aggressive penalties, and temperature, the interaction between home aggressive penalties and temperature was not a significant predictor of visitor aggressive penalties ($\beta = -0.010, r(2318) = -0.515, p = 0.607$). The equivalent analysis, controlling for the same variables, found that the interaction between visitor aggressive penalties and temperature was not a significant predictor of home aggressive penalties ($\beta = 0.003, r(2318) = 0.133, p = 0.895$). This suggests that temperature does not influence the proneness towards reciprocal aggression in football, at least as measured by aggressive penalties.

To determine whether the relationship between temperature and aggressive penalties was linear or non-linear in nature, the standardized temperature values ($z$-scores) were squared and cubed into temperature squared (Temperature$^2$) and temperature cubed (Temperature$^3$). Game points, point spread, non-aggressive penalties, and humidity were entered as control variables. The model was significant ($R^2 = 0.039, F(7, 2318) = 13.419, p < 0.001$). Temperature was significant, primarily the linear temperature term ($\beta = 0.087, p = 0.009$, Table 6 and Fig. 1) and secondarily by the quadratic term ($\beta = -0.049, p = 0.047$).

### 4. Discussion

The goal of this study was to examine whether a linear relationship exists between temperature and aggression in the context of football, an intensely physical contact sport. To do so, we operationalized aggression by classifying certain penalties as aggressive, and then determined whether this relationship held true for both home and away teams.

The present study provides an extension of the previous research in baseball by employing a broader range of available temperatures, and by testing the heat-aggression hypothesis in the context of already substantial aggression inherent in the game. The initial analysis found that temperature had a significant effect on aggressive penalties, coinciding with the previous work demonstrating the relationship between temperature and

#### Table 3
Regression on overall aggressive penalties.

| Measure          | B     | BSE  | β      | t     | p      |
|------------------|-------|------|--------|-------|--------|
| (Constant)       | 0.714 | 0.220| –      | 3.243 | 0.001  |
| Game points      | 0.009 | 0.002| 0.078  | 3.847 | <0.001 |
| Point spread     | −0.008| 0.010| −0.016 | −0.790| 0.430  |
| Non-aggressive penalties | 0.060 | 0.008| 0.158  | 7.715 | <0.001 |
| Humidity         | 0.000 | 0.002| −0.002 | −0.110| 0.912  |
| Temperature      | 0.005 | 0.002| 0.055  | 2.665 | 0.008  |

Note: $R^2 = 0.037, F(5, 2320) = 17.877, p < 0.001$.

#### Table 4
Regression predicting aggressive penalties for the home team.

| Measure          | B     | BSE  | β      | t     | p      |
|------------------|-------|------|--------|-------|--------|
| (Constant)       | 0.220 | 0.143| –      | 1.542 | 0.123  |
| Game points      | 0.004 | 0.002| 0.059  | 2.896 | 0.004  |
| Point spread     | −0.001| 0.006| −0.003 | −0.134| 0.893  |
| Non-aggressive penalties | 0.023 | 0.005| 0.093  | 4.510 | <0.001 |
| Opponent aggressive penalties | 0.144 | 0.020| 0.147  | 7.151 | <0.001 |
| Humidity         | 0.000 | 0.001| −0.005 | −0.235| 0.814  |
| Temperature      | 0.004 | 0.001| 0.060  | 2.890 | 0.004  |

Note: $R^2 = 0.044, F(6, 2319) = 17.752, p < 0.001$.

#### Table 5
Regression predicting aggressive penalties for the visiting team.

| Measure          | B     | BSE  | β      | t     | p      |
|------------------|-------|------|--------|-------|--------|
| (Constant)       | 0.389 | 0.145| –      | 2.680 | 0.007  |
| Game points      | 0.003 | 0.002| 0.043  | 2.124 | 0.034  |
| Point spread     | −0.006| 0.006| −0.018 | −0.893| 0.372  |
| Non-aggressive penalties | 0.028 | 0.005| 0.113  | 5.487 | <0.001 |
| Opponent aggressive penalties | 0.150 | 0.021| 0.147  | 7.151 | <0.001 |
| Humidity         | 0.000 | 0.001| 0.002  | 0.089 | 0.929  |
| Temperature      | 0.001 | 0.001| 0.013  | 0.604 | 0.546  |

Note: $R^2 = 0.043, F(6, 2319) = 17.203, p < 0.001$.

#### Table 6
Regression analysis comparing linear vs. non-linear temperatures.

| Measure          | B     | BSE  | β      | t     | p      |
|------------------|-------|------|--------|-------|--------|
| (Constant)       | 1.116 | 0.186| –      | 5.995 | <0.001 |
| Game points      | 0.009 | 0.002| 0.078  | 3.821 | <0.001 |
| Point spread     | −0.008| 0.010| −0.017 | −0.831| 0.406  |
| Non-aggressive penalties | 0.058 | 0.008| 0.155  | 7.519 | <0.001 |
| Humidity         | −0.001| 0.002| −0.006 | −0.298| 0.766  |
| Temperature      | 0.008 | 0.003| 0.087  | 2.602 | 0.009  |
| Temperature$^2$  | 0.000 | 0.000| −0.049 | −1.988| 0.047  |
| Temperature$^3$  | 0.000 | 0.000| −0.058 | −1.579| 0.114  |

Note: $R^2 = 0.039, F(7, 2318) = 13.419, p < 0.001$. 

To determine whether the relationship between temperature and aggressive penalties was linear or non-linear in nature, the standardized temperature values ($z$-scores) were squared and cubed into temperature squared (Temperature$^2$) and temperature cubed (Temperature$^3$). Game points, point spread, non-aggressive penalties, and humidity were entered as control variables. The model was significant ($R^2 = 0.039, F(7, 2318) = 13.419, p < 0.001$). Temperature was significant, primarily the linear temperature term ($\beta = 0.087, p = 0.009$, Table 6 and Fig. 1) and secondarily by the quadratic term ($\beta = -0.049, p = 0.047$).
The pattern of results changed when aggressive penalties were analyzed separately between home and visiting teams. The relationship was significant for aggressive penalties committed by the home team, but not for those committed by the visiting team. These diverging results imply that the social context also has a role to play in whether temperature will lead to increased aggression. In the context of football, playing in front of supportive fans may garner a sense of high ingroup support, which leads to increased acts of aggression towards opposing teams, and allows temperature to play a significant role in being overly aggressive towards the visiting team. This finding has relevance for other domains in which intergroup interactions occur, particularly between dominant groups and weaker groups. For example, developmental research considering peer group effects on bullying have supported the relationship of social groups on aggression when studying adolescent bullying. However, the interpretation of these results should be taken cautiously as the expected interaction was not significant, perhaps due to power issues and few games being played at exceptionally high temperatures (more than 85°F).

The total amount of variance explained was significant when entering in both linear and non-linear terms simultaneously, with both the linear and non-linear term β coefficients significantly predicting aggressive penalties. The variance accounted for was similar to those reported by the previously discussed baseball studies. This, along with the higher value of the β weight for the linear term relative to the non-linear term, suggests that aggressive penalties are more frequently performed in hot weather. Researchers have argued a primarily linear heat-aggression relationship, with hotter temperatures leading to more aggression and cooler temperatures leading to less aggression. Although there is some dispute on whether there is a linear or curvilinear relationship between temperature and aggression, the weight of the evidence is for a linear relationship once proper methodological approaches are utilized, and the present study generally supports a linear relationship.

A few limitations arise in the present analysis. Given that the identification of penalties requires the subjective judgment of refereeing officials, an analysis would not be comprehensive without considering and controlling for their involvement. However, the present dataset lacks any data on referees. A future study would be helpful in delineating the influence of referees, as perhaps irritated or hot referees may be prone to call penalties, particularly those labeled here as aggressive. As a corollary, the size of the crowd may influence both the group dynamics and the referees’ judgments. Heat and irritation increases the perception of aggression in others. A related limitation is that there is only one measure of aggression in the present study, which could be bolstered by other measures not available in the present data, such as type and frequency of injuries.

Also, the present study is not immune to the problem of restriction of range, which is an issue in temperature-aggression research. When looking at large datasets with the primary interest being effects at the tails of the distribution sample, the bulk of the sample tends to gravitate around the mean (normal curve) and this tends to outweigh patterns occurring at the extremes of the distribution in analyses. Given that extremely high temperatures are uncommon and moderate temperatures are more common, this leads to less information to utilize when considering these extremes. Also, modern football stadiums are usually built to be cool and air-conditioned, further restricting the range of temperature data points in the present study.

Somewhat related to the range limitation, the second limitation notes that although the analysis suggested the relationship between temperature and aggressive penalties in football to be linear, close consideration of Fig. 1 would show a small dip in temperatures somewhat consistent with a curvilinear relationship as the significant non-linear term indicates, implying that the current data should be interpreted cautiously. The reason may be that while irritability increases at extremely high temperatures, heat stress and fatigue also increase with high physical activity, leading to reduced ability to commit aggressive physical acts in the context of an intensely athletic game such as football. This explanation is drawn from research studying environmental effects as heat on industrial work and construction, as well as reasonable speculation in the heat hypothesis literature that significant physical activity contributing to violence is unlikely in temperature outside the normal range.

5. Conclusion

High temperature leads to increased aggression, and this relationship appears in many areas of life. This study generalizes this relationship to the sport of football, and suggests that...
the temperature and aggression relationship is linear. Furthermore, the relationship appears to be affected by social context, with only home team aggression being affected by high heat, which has implications for intergroup conflict. Future research should consider other social contexts that may be relevant to see if these results generalize, and also determine how heat influences aggressive acts even in situations of high conflict, such as civil disputes, protests, and warfare.11

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Authors’ contributions

CC conceived of the study, participated in its analysis and helped draft the manuscript. RWO managed the dataset, conducted the primary statistical analyses, and built the figures and tables. MVC participated in its design and helped to draft the manuscript. SBR coordinated the study and helped draft and finalize the manuscript. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

Competing interests

None of the authors declare competing financial interests.

References

1. Keller MC, Fredrickson BL, Ybarra O, Cote S, Johnson K, Mikels J, et al. A warm heart and a clear head: the contingent effects of weather on mood and cognition. Psychol Sci 2005;16:724–31.
2. Anderson CA. Temperature and aggression: ubiquitous effects of heat on occurrence of human violence. Psychol Bull 1989;106:74–96.
3. Anderson CA, Bushman BJ, Groom RW. Hot years and serious and deadly assault: empirical tests of the heat hypothesis. J Pers Soc Psychol 1997;73:1213–23.
4. Baron RA, Bell PA. Aggression and heat: the influence of ambient temperature, negative affect, and a cooling drink on physical aggression. J Pers Soc Psychol 1976;33:245–55.
5. Anderson CA, Bushman BJ. Human aggression. Annu Rev Psychol 2002;53:27–51.
6. Berkowitz L. Some effects on anti- and prosocial influences of media events: a cognitive-neoassociation analysis. Psychol Bull 1984;95:410–27.
7. DeWall CN, Anderson CA, Bushman BJ. The general aggression model: theoretical extensions to violence. Psychol Violence 2011;1:245–58.
8. Hsiang SM, Burke M, Miguel E. Quantifying the influence of climate on human conflict. Science 2013;341:1253567. doi: 10.1126/science.1253567.
9. Crutzen PJ. Geology of mankind. Nature 2002;415:23. doi:10.1038/415023a.
10. Tirt J, Diehl PF. Demographic pressure and interstate conflict: linking population growth and density to militarized disputes and wars, 1930–89. J Peace Res 1998;35:319–39.
11. Anderson CA, DeLisi M. Implications of global climate change for violence in developed and developing countries. In: Forgas J, Kruglanski A, Williams K, editors. The psychology of social conflict and aggression. New York, NY: Psychology Press; 2011:249–65.
12. Mackie DM, Devos T, Smith ER. Intergroup emotions: explaining offensive action tendencies in an intergroup context. J Pers Soc Psychol 2000;79:602–16.
13. Wilson ML, Hauser MD, Wrangham RW. Does participation in intergroup conflict depend on numerical assessment, range location, or rank for wild chimpanzees? Anim Behav 2001;61:1203–16.
14. Reifman AS, Larrick RP, Fein S. Temper and temperature on the diamond: the heat-aggression relationship in major league baseball. Pers Soc Psychol Bull 1991;17:580–5.
15. Larrick RP, Timmerman TA, Carton AM, Abrevaya J. Temper, temperature, and temptation: heat-related retaliation in baseball. Psychol Sci 2011;22:423–8.
16. Littleton A, Guskiewicz K. Current concepts in sports concussion management: a multifaceted approach. J Sport Health Sci 2013;2:227–35.
17. Selassie AW, Wilson DA, Pickelsimer EE, Voronca DC, Williams NR, Edwards JC. Incidence of sport-related traumatic brain injury and risk factors of severity: a population-based epidemiologic study. Ann Epidemiol 2013;23:750–6.
18. Seichepine DR, Stamm JM, Daneshvar DH, Riley DO, Baugh CM, Gavett BE, et al. Profiles of self-reported problems with executive functioning in college and professional football players. J Neurotrauma 2013;30:1299–304.
19. Allen MS, Jones MV. The “home advantage” in athletic competitions. Curr Dir Psychol Sci 2014;23:48–53.
20. Bushman BJ, Wang MC, Anderson CA. Is the curve relating temperature to aggression linear or curvilinear? Assaults and temperature in Minneapolis reexamined. J Pers Soc Psychol 2005;89:62–6.
21. Bell PA. Reanalysis and perspective in the heat-aggression debate. J Pers Soc Psychol 2005;89:71–3.
22. Cohn EG, Rotton J. The curve is still out there: a reply to Bushman, Wang, & Anderson’s (2005) “Is the curve relation temperature to aggression linear or curvilinear?”. J Pers Soc Psychol 2005;89:67–70.
23. Bushman BJ, Wang MC, Anderson CA. Is the curve relating temperature to aggression linear or curvilinear? A response to Bell (2005) and to Cohn and Rotton (2005). J Pers Soc Psychol 2005;89:74–7.
24. Armchair Analysis. Game-level data files. Available at: http://www.armchairanalysis.com/ [accessed 26.03.2011].
25. Toftum J, Jörgensen AS, Fanger PO. Upper limits of air humidity for preventing warm respiratory discomfort. Energ Build 1998;28:15–23.
26. Cohen D, Nisbett RE, Bowdle BF, Schwarz N. Assault, aggression, and the southern culture of honor: an “experimental ethnography”. J Pers Soc Psychol 1996;70:945–60.
27. Anderson CA, Anderson KB. Temperature and aggression: paradox, controversy, and a (fairly) clear picture. In: Geen R, Donnerstein E, editors. Human aggression: theories, research and implications for policy. San Diego: Academic Press; 1998.p.247–98.
28. Anderson CA, Anderson KB. Violent crime rate studies in philosophical context: a destructive testing approach to heat and southern culture of violence effects. J Pers Soc Psychol 1996;70:746–50.
29. Anderson CA, Anderson KB, Dorr N, DeNeve KM, Flanagan M. Temperature and aggression. Adv Exp Soc Psychol 2000;32:63–133.
30. Hancock PA, Vasmatzidis I. Effects of heat stress on cognitive performance: the current state of knowledge. Int J Hyperthermia 2003;19:355–72.
31. Ramsey JD. Task performance in heat: a review. Ergonomics 1995;38:154–65.
32. Espelage DL, Holt MK, Henkel RR. Examination of peer-group contextual effects on aggression during early adolescence. Child Dev 2003;74:205–20.
33. Salmivalli C. Bullying and the peer group: a review. Aggressive Violent Behav 2010;15:112–20.
34. Koenh E, Brown G. Climatic effects on construction. J Constru Eng Manage 1985;111:129–37.
35. Carlsheim JM, Anderson CA. Ambient temperature and the occurrence of collective violence: a new analysis. J Pers Soc Psycho 1979;37:337–44.