Hot Temperatures, Hostile Affect, Hostile Cognition, and Arousal: Tests of a General Model of Affective Aggression

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Hot Temperatures, Hostile Affect, Hostile Cognition, and Arousal: Tests of a General Model of Affective Aggression

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A general model of affective aggression was used to generate predictions concerning hot temperatures. Experiment 1 examined hot temperature effects on hostile affect, hostile cognition, perceived arousal, and physiological arousal in the context of a study of video games. Experiment 2 examined hot temperature effects on hostile affect, perceived and physiological arousal, and general positive and negative affect in the context of brief aerobic exercise. Consistent results were obtained. Hot temperatures produced increases in hostile affect, hostile cognition, and physiological arousal. Hot temperatures also produced decreases in perceived arousal and general positive affect. These results suggest that hot temperatures may increase aggressive tendencies via any of three separate routes. Hostile affect, hostile cognitions, and excitation transfer processes may all increase the likelihood of biased appraisals of ambiguous social events, biased in a hostile direction.

Social theories relating heat stress to aggressive behavior and aggression-related affects can be found in writings as ancient as those of the Rome of Cicero (106-43 B.C.) and as recent as last summer's newspapers. References to hot temperatures producing aggression can be found in works as hallowed as Shakespeare's *Romeo and Juliet* and as obscure as a 1985 Ohio State student newspaper cartoon. If consensus were truth, then scientific investigation of the hypothesis that temperature influences aggression would be unnecessary.

But consensus is not truth; it provides no evidence relevant to the validity of the social theory. Demonology as a social theory of aberrant behavior was a widely held belief, but the belief failed to prove either the existence of demons or their role in mental illness. Thus the temperature-aggression hypothesis has appropriately received considerable empirical attention in the last 100 years, as various social philosophers, social geographers, and others have wrestled with the problems of violence in society (e.g., Aschaffenburg, 1903/1913; Dexter, 1899; Lombroso, 1899/1911).

A recent review revealed that the relation between temperature and aggression-related variables is neither as clear nor as simple as the consensus social theory would have it (Anderson, 1989). It is true that archival data and field studies demonstrate that hotter temperatures are associated with increases in aggressive behavior of many types, including murder, rape, assault, family disturbances, and spouse abuse. Furthermore, the wide range of methodologies used in those studies and the consistency of their findings make the obvious alternative explanations implausible. The theoretical gains from this nonlaboratory literature, however, have been meager. At present there is no well-supported theory of the temperature-aggression relation, because of a host of problems.

PROBLEMS WITH THE CURRENT STATE OF KNOWLEDGE

First, the archival and field studies do not test theories designed to explain why hot temperatures are associated

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with increased aggressiveness. This is because the kinds of additional variables needed—such as the arousal, affective, and cognitive states of the target populations—are simply unavailable for analysis. Studies of violent and nonviolent crime can tell us about patterns of behavior but not about hypothesized mediating variables.

The inability of archival and field studies to address fine theoretical points suggests the testing of these theories in laboratory settings. Major attempts in this direction have been made, primarily by Baron and Bell (e.g., 1976; see also Baron, 1979). Here, the second major problem arises: The many laboratory experiments that have examined the temperature-aggression relation have produced markedly inconsistent findings (Anderson, 1989; Anderson & DeNeve, 1992). There are several plausible reasons for this state of affairs, one of which involves subject reactivity problems. Specifically, subjects participating in hotter conditions may be more suspicious about the true purpose of the experiment, especially when the main task involves delivering shock or other harm to another person. If this happens, subjects in the hot conditions may artifactually decrease their aggression (cf. Anderson, 1989; Rule & Nesdale, 1976). If the obviousness of the experimental situation or the stage management skills of experimenters varies between studies, or if the strength or accessibility of the underlying social theory varies in the different subject populations, the result will be inconsistent temperature effects.

A third, and related, problem concerns the limited range of dependent variables used in past laboratory work. With only a few exceptions, the past work has focused on aggressive behavior rather than the broader class of aggression-related behavior relevant to the temperature-aggression hypothesis. That is, the hypothesized effects of hot temperatures on variables such as hostility, anger, and general positive and negative affect have received scant attention. This narrowness is understandable in light of the apparent goal to establish a consistent pattern of results linking temperature to behavior. However, the inconsistencies of past results, the potential artifactual problem, and the need to assess potential mediators all suggest that a new line of inquiry may be more fruitful at the present time.

In our view the most fruitful approach consists of two parts. First, the research needs to be grounded in a solid and general theoretical context, one that relies on a broadly based theory of affective aggression, rather than in a specific theory derived mainly to deal with temperature. Second, the research needs to examine the effects of temperature on the whole range of variables suggested by the broad theory. This article presents a broad theory of affective aggression, notes how temperature may influence several processes delineated in the theory, and presents two experiments designed to test the effects of temperature on several variables that may mediate the temperature-aggression relation. More specifically, the theory reveals that hot temperatures may increase aggressive tendencies by priming hostile feelings, by priming hostile cognitions, or by increasing physiological arousal. The reported experiments test the viability of each possibility.

A THEORY OF AFFECTIVE AGGRESSION

Similarity of Models

We examined key theories and research in this domain to derive testable predictions that do not rely on reactive behavioral measures of aggression. The theories are Berkowitz's cognitive-neoassociationistic analysis of aggression (e.g., 1990), Baron and Bell's negative affect escape model (e.g., Baron, 1979), and Zillmann's theory of excitation transfer (e.g., 1983).[1] Geen's (1990) analysis of affective aggression provides an excellent framework for understanding the more specific phenomena to which the other theories refer.

Although these are separate theories, they overlap in many important respects. For example, the Berkowitz (1990) model emphasizes the importance of cognitive associations. It predicts that uncomfortable conditions should automatically prime aggressive thoughts and feelings, perhaps even to the extent of influencing memories. Because expressive-motor programs (or schemata) are included in the list of possible associates in the cognitive network, the model can also handle effects of temperature on some measures of subjective and objective arousal. This provides some overlap with Zillmann's (1983) approach, for arousal is its major component. As applied to the temperature-aggression effect, unexplained arousal from uncomfortably hot temperatures may be transferred or "misattributed" to a more salient anger-producing source, such as an insulting interaction partner.

Similarly, although the negative affect escape model focuses on aggressive behavior, it also hypothesizes that negative affect underlies the effects of temperature. Specifically, negative affect is seen as increasing aggressive motives and is seen as resulting from hot temperatures. Thus this and Berkowitz's models predict a temperature effect on general negative affect. In addition, if we view affective aggression as being motivated by feelings of anger or hostility, then both models make the same prediction regarding the effects of hot temperatures on these more specific types of negative affect.

An Integrated Theory of Affective Aggression

Figure 1 displays our theory of affective aggression. As noted earlier, it borrows heavily from many sources. For

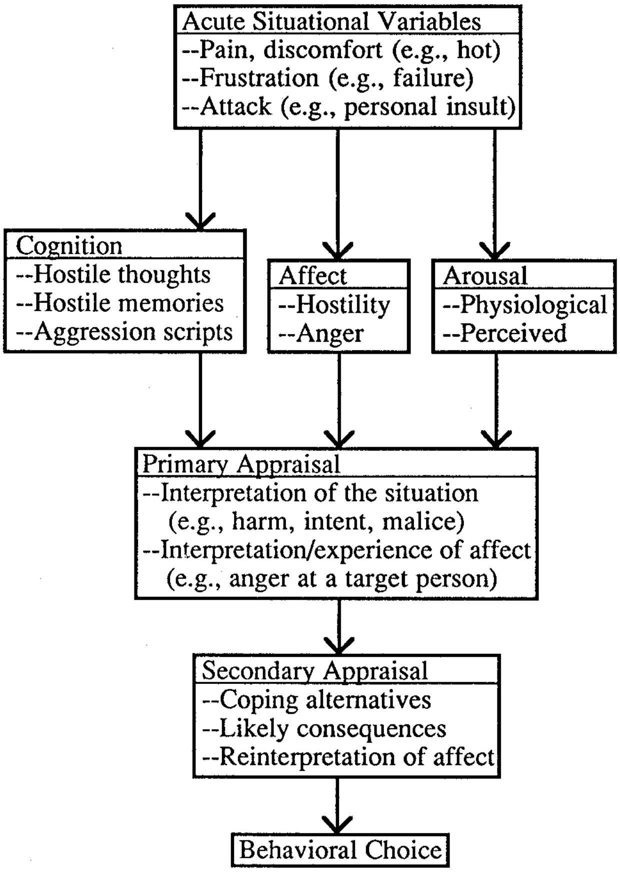

Figure 1 **An integrated theory of affective aggression.**

related ideas, supporting research, and more specific details of this approach, interested readers will find Geen (1990) and Berkowitz (1990) particularly helpful.

BASIC INPUT

At the first level we enter the model with acute situational variables. These may be anything in the current situation that influences the person's current state. Being uncomfortably hot (vs. comfortably cool) is one such variable. Frustrating events or physical or verbal attacks are other acute events of particular relevance to the instigation of aggression. Multiple situational variables, each of which is "annoying" in some way, likely produce additive (and possibly multiplicative) effects. The background level of annoyance must be at a level that allows additional annoyances to produce an effect on the cognitive, affective, and arousal variables. If the person is already enraged, then hot temperature is unlikely to have additional effect. Conversely, if the person is in an extremely positive state, then brief exposure to hot temperatures is unlikely to have any impact. What it takes to reach the optimal background level of annoyance is impossible to specify in advance. For this reason, Experiment 1 included a two-level frustration manipulation. We hoped that at least one level of frustration would produce a background level of annoyance that would be sensitive to temperature effects.

Acute situational variables influence the current state of the person by influencing the interpretation and understanding of incoming information. Certain types of interpretations become more likely, whereas others become less likely, via standard schematic processes that produce cognitive and motivational biases in the explanation process (e.g., Kruglanski, 1989). Thus a person who is uncomfortably hot or has been insulted or who is in pain is relatively more likely to access hostility-related schemata than a person who is comfortable, praised, or experiencing pleasure.

Schematic knowledge structures include thoughts, feelings, memories, and behavioral scripts, and tend to be linked in memory in meaningful ways. Affect may well indeed be a prime source of organization of such networks, although such a claim is not central to our theory. What is central is the idea that activation of one element in a network tends to increase automatically the accessibility of other elements in that network, as a function of the strength of the linkage and the strength of the initial activation. Thus seeing the name of your old nemesis "Joe Snerd" in the newspaper may be sufficient to (a) activate old memories about how he unfairly disparaged your work, (b) reinstate the hostile feelings you experienced, and (c) get you plotting your revenge. Furthermore, such priming may spread to other hostility-related memories, thoughts, and scripts. In brief, acute situational variables can prime aggression-related cognitions, affects, or both.

Acute situational variables have another pathway to aggression. Many such variables influence the person's state of arousal. Pain, for instance, tends to increase arousal. As noted in the figure, it is important to distinguish between physiological arousal and the person's perception or feeling of arousal. Such arousal effects may influence later variables in the model through excitation transfer processes.

PRIMARY APPRAISAL

The second level begins with three types of states. One concerns the cognitive schemata that are available for use in processing incoming information. A second concerns the affective state through which the incoming information is filtered. The third concerns the state of arousal.

Primary appraisal is seen as immediate, automatic, and very fast. It requires relatively little cognitive effort. People interpret both the current situation and their own affective state quickly, with particular reference to harm, intent, and malice, as well as feelings of anger. Schemata that are currently most accessible influence these interpretations, especially when the situation is ambiguous. Obviously, if Joe Snerd punches you in the nose, there is little room for schematic biases in interpretation. People with an active friendliness schema will arrive at much the same interpretation as those with an active hostility schema.

However, social situations are often unclear in meaning. If Joe Snerd apologizes to you for previously disparaging your work, your interpretation of the apology, your affective reaction, and, ultimately, your behavioral response may very well depend on which type of schema was active. A hostile schema might lead you to look for and find self-serving motives behind the apology, whereas a friendliness schema might yield a magnanimous interpretation. Current affective state will have much the same effect on primary appraisal, although the processes producing the similar effects will differ (Kruglanski, 1989).

State of arousal can also influence one's primary interpretation, as Zillmann (1971, 1983) has shown in a variety of contexts. Unexplained arousal from a subtle source may be misattributed to a more salient event or person in the immediate situation. This excitation transfer can increase the affective response to the salient event, but it cannot change the direction of the response. That is, excitation transfer can increase the positive reaction to a positive event, or the negative reaction to a negative event, but it cannot make one like a negative event or dislike a positive event.

SECONDARY APPRAISAL AND BEYOND

When time and cognitive resources are available, the results of primary appraisal processes are further evaluated in a more thoughtful, effortful, and conscious secondary appraisal process. Additional information may be brought to bear, information that may completely override that primary appraisal. For example, you may learn that Joe Snerd hit you because he had just been told that you had shot his wife. Although no such shooting had taken place, the fact that you believe that Joe believed it to be true will lead you to reinterpret the meaning of the punch in the nose. Other aspects of secondary appraisal include consideration of various behavioral responses to the punch, your ability to carry them out, and the likely consequences of these alternatives. Additional attribution and related decision processes occur at this stage, ultimately leading to a behavioral response. These are not the focus of our current work, however, and will not be further discussed in this article.

The Case for Temperature

This general theory of affective aggression suggests three possible routes for hot temperature effects on a variety of variables. One route is through the currently accessible schemata. Hot temperatures may prime hostile thoughts and memories as well as hostile affective states. Both routes may then lead to systematically more hostile interpretations of ambiguous events and of one's own ambiguous affective states, and, ultimately, to more aggression. The third route is through arousal. If hot temperatures increase arousal, then excitation transfer processes may contribute to the temperature-aggression effect. But how do we conceptualize and measure arousal? We opted to assess both physiological arousal and perceived arousal, because the existing literature suggests that increases in aggression are likely to be maximized when residual physiological arousal is relatively high at the same time that perceptions of arousal are low (e.g., Cantor, Zillmann, & Bryant, 1975).

In sum, testing the general theory of affective aggression in the temperature domain requires examining the effects of heat on hostile feelings, hostile cognitions, perceived arousal, and physiological arousal. In addition, general positive and negative affect was deemed worth exploring.

A HOT EXAMPLE

How might hot temperatures contribute to violence in society? Imagine yourself in the following scenario. You are driving home from work on a crowded highway. It is mid-August, your air conditioner is not working, and you are hot. Hostility-related schemata are primed because of the discomfort. The heat has also increased your general level of arousal. You feel miserable. Suddenly, the black Firebird that has been tailgating you speeds past and then cuts you off, almost forcing an accident. A typical reaction, perhaps yours, would be to experience high anger, to interpret the action as intentionally aggressive, and to blast the horn. Such encounters have led to shoot-outs in a number of U.S. cities in recent years.

How would a functional air conditioner change this scenario? Theoretically, a comfortably cool person would be less likely to have hostility schemata primed, would not feel so hostile, and would not experience a temperature-based increase in general arousal. Thus the Firebird episode would be less likely to elicit an aggressive interpretation; the action may be seen as simply foolish, rather than hostile.

Obviously, such temperature effects are unlikely to prove the most important factor in affective aggression. Just as obviously, the general theory predicts that such effects should control some amount of variance in cognitions, affect, interpretations, and, ultimately, behavior. In the many ambiguously aggressive encounters that occur daily, uncomfortably hot temperatures are likely to ignite already inflammable tempers in at least some cases.

PAST WORK ON AFFECT, COGNITIVE STATE, AND AROUSAL

Affect

Past laboratory studies have looked at temperature effects on affect, although none have explicitly focused on feelings of hostility or anger. In most studies the affect measures were used primarily as manipulation checks. For instance, it has been shown that people in hot rooms rate the rooms (or themselves) as hotter, more unpleasant, and more uncomfortable than do subjects in normal temperature rooms (Baron & Bell, 1975, 1976; Bell & Baron, 1974; Bell, Garnand, & Heath, 1984; Griffitt, 1970; Griffitt & Veitch, 1971).

Griffitt and Veitch (1971) included a state measure of aggressive affect and provided the only supportive evidence to date of temperature effects on aggression-related affect. Subjects completed a variety of mood-related items under either hot or normal temperature conditions. Results showed significant temperature effects on many mood variables. One such variable was aggression, which was significant at the .05 level. However, a previous study using similar procedures and measures did not find aggression to be significantly influenced by temperature (Griffitt, 1970). Interestingly, both studies showed that hot temperatures produced lowered levels of attraction to a target stranger, although this effect was only marginally significant ($p < .07$) in Griffitt and Veitch (1971). In sum, we believe that Griffitt's studies do support our theory, but we had to admit that those data were somewhat weak and in need of replication and more direct attention. Both of our experiments do this.

Cognitive State

Only one study has examined the effects of hot temperatures on variables that might be seen as indicators of cognitive state. Rule, Taylor, and Dobbs (1987) asked subjects to read and to complete story stems under normal or hot conditions. Some of the story stems were aggression relevant, whereas others were not. Content analyses of the written completions revealed an interesting interaction. For aggressive story stems, heat appeared to increase the proportion of aggressive elements. However, this did not occur for neutral story stems. Although intriguing, these results do not provide as much support for the general model as a first reading might indicate. One problem concerns the failure to get a temperature effect when the stems were neutral. The theory does not require any other sort of aggressive prime for temperature effects to operate. A second problem concerns the separability of the cognitive from the affective. Perhaps the aggressive elements simply reflected a priming of affective components, rather than a priming of cognitive elements. The results of Rule et al. are suggestive but not conclusive.

Experiment 1 included measures of cognitive state that were more clearly separable from affect. In addition, several procedural features were included to allow stronger tests of the general model.

Arousal

The relation of various physiological measures of arousal to temperature variations is far from clear, although there are hints that hot temperatures increase heart rate, decrease self-reported arousal, and increase activity level (Anderson, 1989; Bell, 1981; Rotton, 1985; Rotton, Shats, & Standers, 1990). In addition, the relation between physiological indicators of arousal and self-reported arousal is often quite weak (see Cacioppo & Petty, 1986). Finally, the relevance of perceptions of arousal to an excitation transfer model is unclear. The results of at least one study (Cantor et al., 1975) suggest that the discrepancy between perceived arousal and physiological arousal is crucial in excitation transfer. Specifically, excitation transfer seems to occur when physiological arousal is somewhat elevated while concomitant perceptions of arousal are not. Thus both of the present experiments included several simple physiological measures of arousal and a measure of perceived arousal to explore these possibilities.

An additional issue concerns the measurement of physiological arousal. Many have questioned the whole concept of some generalized physiological arousal. Among those researchers who find the concept useful, there is disagreement on how best to measure it. Certainly the best measures are likely to differ from one experimental context to another. We have chosen to assess heart rate and blood pressure, for several reasons. First, these have been successfully used in a variety of excitation transfer studies (e.g., Zillmann, 1971). Second, we needed noninvasive procedures. Third, other popular measures such as various electrodermal ones (Blascovich & Kelsey, 1990) were deemed inappropriate for assessing arousal under varying temperature conditions. The increased sweat gland activity in hot temperatures would render interpretation of such measures difficult: Is it truly arousal or merely thermoregulation? This last point also raised concerns about the value of the blood pressure measures. Specifically, we know that one thermoregulatory mechanism involves dilation of peripheral blood vessels to increase heat transfer from the skin; this may also reduce blood pressure and thus counteract any increase in true arousal produced by hot temperatures. Thus heart rate was expected to be the best indicator of physiological arousal. We assessed blood pressure also, mainly because of its use in past related research.

OVERVIEW OF BOTH EXPERIMENTS

Our goal in these experiments was to test the viability of each of the three proposed routes for temperature effects on aggressive behavior. That is, we wanted to see which route(s) could serve as potential explanations for the temperature-aggression relation obtained in previous studies. Subsequent research can then focus on following up the route or routes that yield reliable temperature effects. Thus we did not assess aggressive behavior in these studies. This approach yields both theoretical and practical results. Theoretically, a route that fails to show reliable temperature effects cannot account for phenomena that occur later in the model (e.g., appraisal and behavioral effects). Practically, this means that subsequent research can and should focus on the most promising pathways through the model.

EXPERIMENT 1

The purpose of Experiment 1 was to examine the effects of hot (compared to normal) temperatures on arousal, cognitive state, and hostile affect. Both perceived arousal and physiological arousal were assessed. Frustration level was also manipulated to increase the chances that an appropriate background level of annoyance was included.

Method

DESIGN AND OVERVIEW

The experiment employed a 2 (Frustration) × 3 (Temperature) factorial design that crossed frustration level (low vs. moderate) with temperature (comfortable, warm, and hot). Participants were randomly assigned to one of these six conditions. Frustration was manipulated by having the participant play a Pac Man-type video game with the joystick either in the normal position (low frustration) or in an inverted position (moderate frustration). The main purpose of having subjects play the video game was to occupy their time while experiencing the assigned temperature. Furthermore, the video game provided the cover story. Room temperature was controlled by air conditioning and heating equipment that was adjusted and set prior to the room's use. Humidity was controlled by a portable humidifier and was kept at about 40% for all conditions.

PARTICIPANTS

A total of 59 female and 48 male undergraduates at a large midwestern university completed all materials. They received class credit for participating. Each person was run individually. Each session took approximately 75 minutes.

PROCEDURE

On arrival, participants were told that they would be performing two separate unrelated studies being run as part of a class project. To aid in the believability of this cover story, consent was obtained for each of the two studies and different experimenters ran them. It was explained that the first study was being conducted to determine what effects, if any, temperature would have on concentration on a cognitively involving task (a video game) and on several physiological measures. The second was described as a survey of current beliefs and attitudes prevalent on campus. Recent public discussions about rapes on campus made the survey cover story particularly convincing.

Phase 1. Shortly after arriving, each participant provided background information (age, sex, class), typical number of hours of exercise per week, height, and weight. The latter measures were taken as part of the cover story. Participants were told that they would play a challenging video game in a temperature-controlled room in which the temperature had been set to one of the three temperature conditions: normal, warm, or hot. After these instructions were given, the participant's blood pressure and pulse were measured twice, with a 10-second interval between measurements to prevent invalid readings because of constricted blood flow from the first measurement. Participants were told that these measures were being taken to additionally examine the effects of temperature on physiological measures, to see how they all relate to cognitive performance. It was explained that this first set of physiological measures was to establish a baseline.

Next, participants were escorted to the game room, which was randomly set to one of the three temperatures in advance. Because of the age of the building in which the temperature lab resides, it was not possible to control temperature precisely. The actual ranges were 72°F-78°F for the comfortable condition, 79°F-86°F for the warm condition, and 87°F-94°F for the hot condition. The joystick used to play the video game was placed either in a normal position (for the low-frustration condition) or in an inverted position (for the moderate-frustration condition). Experimenters were unaware of these manipulations until they escorted the subject to the game room. After arriving at the game room, the participant was told the following:

> This is the video game that was mentioned earlier. Please take your performance seriously as I would like you to

> play the game to the best of your ability for the next 10 minutes. Please tell me if you finish the game before the time is up and I will record your score and restart the machine for you. I will tell you when to begin and when your time is up.

After the instructions were read, the game was demonstrated, and procedural questions were answered, physiological measurements were taken again. Participants played the game for 10 minutes, after which the physiological measures were recorded a third time. Participants then completed three sets of rating scales.

The first set measured perceptions of the video game. Participants rated the ease, enjoyability, frustration, violent content, violent graphics, pace of action, and length of pauses that were associated with the game using 7-point scales (Anderson & Ford, 1986).

The second set of scales measured self-reported arousal. Sixteen adjectives were rated on 7-point scales (1 = *does not describe how I feel at all* to 7 = *accurately describes how I feel*). Eight of the adjectives reflected high arousal, whereas the other eight reflected low arousal. A total arousal score was derived by reverse scoring the low-arousal subscale and then summing the two subscales. Thus, the higher the total score, the greater the arousal that was reported (see appendix for the Perceived Arousal Scale [PAS]).

The third set was described to participants as a Current Mood Scale. This scale was actually designed to measure state hostility. A total of 35 self-relevant statements containing anger- and hostility-related adjectives and actions from the Multiple Affect Adjective Check List (MAACL; Zuckerman, Lubin, Vogel, & Valerius, 1964) and the State Anger Scale (Spielberger, Jacobs, Russell, & Crane, 1983) were rated on a 5-point Likert-type scale (1 = *strongly disagree*, 2 = *disagree*, 3 = *neither agree nor disagree*, 4 = *agree*, 5 = *strongly agree*). Subjects received the following written instructions: "Please indicate the extent to which you agree or disagree with each of the following mood statements. Use the following 5-point rating scale. Write the number corresponding to your rating on the blank line in front of each statement." Each item consisted of the sentence frame "I feel x," where x was the adjective or action. For example, one adjective-based item was "I feel discontented"; one action-based item was "I feel like banging on the table." Eleven were items such as "I feel polite"; such items were reverse scored. All items were then summed to form a composite measure of state hostility.

Next, physiological measures were taken a fourth time. In keeping with the cover story, participants were given a bogus debriefing and a department experiment evaluation form, and they were told to report to another room for the second study. Although the debriefing times varied slightly, most participants were on their way to the second study within 10 minutes.

Phase 2. Participants were greeted by a second experimenter of the same sex as the participant. This experimenter was unaware of the temperature and the frustration condition of the subject. The participant was told the following:

> We are senior psychology students interested in attitudes of the population of the university toward current issues. Our study will give us information about student views and general attitudes. All data that are collected will remain confidential, and your responses will remain anonymous.

Consent for the second experiment was then obtained, and the participant was given a packet of questionnaires and instructed to "read each item carefully and answer honestly and accurately according to your current mood and attitude. When you finish the questionnaire, place it in the appropriate envelope." A large manila envelope with the questionnaire title written on it was available for each of the three questionnaires. A separate envelope was used to collect consent forms. The consent envelope contained numerous consent forms, so that subjects would believe that their responses were indeed anonymous.

The scales were as follows: 33 items from the Assault, Irritability, and Verbal subscales from the Hostility Inventory (Buss & Durkee, 1957); 26 items from the Extreme Interpersonal Violence, Corporal Punishment of Children, and Penal Code Violence subscales of the Attitudes Toward Violence Scale (Velicer, Huckel, & Hansen, 1989); and 11 items from the Rape Myth Scale (Burt, 1980). These three questionnaires were labeled "Expressed Behavioral Tendencies," "Current Issues," and "Campus Issues," respectively. Items were rated using a 5-point Likert-type scale (1 = *strongly disagree*, 2 = *disagree*, 3 = *neither agree nor disagree*, 4 = *agree*, 5 = *strongly agree*).

Each scale was originally designed to measure specific stable components of aggression, hostility, and anger. The Buss-Durkee (1957) scale consists of self-descriptive statements summarizing past hostile behaviors or feelings; in other words, the items assess beliefs about one's own hostility. The Velicer et al. (1989) and the Burt (1980) scales measure violence- or aggression-related attitudes or beliefs. From our perspective, these scales all measure cognitions concerning hostility and aggression. Priming one's hostility schemata should increase the accessibility of memories of one's past aggressive behaviors, for instance, thus increasing the endorsements of hostile behavior items. Preliminary analyses revealed substantial intercorrelations between these scales, so the items from the three scales were combined into a composite measure of hostile cognition (after reverse scoring when appropriate).

The final debriefing was designed to uncover any suspicions subjects might have had about the true nature of both of the experiments. It was apparent that six participants had guessed correctly at some aspect of the hypotheses; they were not included in the data analyses. The nature and reason for the deception involved in the experimental manipulations were explained, and questions about any aspect of the experiment were answered.

Experimenters. Five different research teams conducted the experiment. Each team was composed of three undergraduates. Each person within each team served in each of the two roles (Experimenter 1 or Experimenter 2). Role assignment was random, within the constraints of time schedules and the necessity of always having Experimenter 2 be of the same sex as the subject.

Notes on the physiological measures. The heart rate and blood pressure measures were taken with an oscillometric automatic constant-air-release blood pressure meter with a digital display (A & D Engineering, Model UA-701). This automatic device was used so that extensive training of experimenters would not be necessary. Subjects were not allowed to see their measures until after the first phase of the experiment was completed.

Results

PRELIMINARY ANALYSES

Temperature control. Actual temperatures varied somewhat within each of the three temperature conditions. Thus a regression approach with temperature as a continuous variable was used to estimate more precisely the effects of temperature. Analyses of variance using the three-level temperature manipulation revealed essentially the same results, although in a few cases, the results were slightly weaker.

Scale reliabilities. Item-total correlations suggested eliminating 1 item from the PAS, leaving a total of 15 items. Cronbach's alpha was then computed for each of the three composite dependent variable scales. In each case the internal reliability was quite high: state hostility = 0.93, hostile cognition = 0.91, and perceived arousal = 0.92.

Frustration manipulation check. As expected, the video game was rated as more frustrating when the joystick was upside down than when it was in the correct orientation, $F(1, 103) = 30.38$, $p < .0001$. There were no other significant effects. The means for the low- and moderate-frustration conditions were 2.71 and 4.46, respectively.

MAIN ANALYSES

Perceived arousal. The possible range of scores was 15 to 105. A series of regression analyses was conducted that examined all interaction and quadratic terms. The quadratic terms were included to test for any possible curvilinear relations between temperature and aggression.[2] There were no significant quadratic effects ($ps > .29$).

A main effect of frustration demonstrated that persons in the low-frustration condition perceived themselves as less aroused than persons in the moderate-frustration condition, $F(1, 100) = 7.56$, $p < .008$, $Ms = 45.7$ and 48.9, respectively. The main effect of temperature was marginally significant, $F(1, 100) = 3.65$, $p < .06$. Perceived arousal decreased when temperature increased. The main effect of the sex of the participant was not significant ($p > .08$).

The Sex × Frustration interaction was significant, $F(1, 100) = 8.25$, $p < .006$. Females reported considerably less arousal than males did in the low-frustration condition ($Ms = 39.4$ and 53.1 for females and males, respectively), but they reported slightly more arousal than males did in the moderate-frustration condition ($Ms = 50.2$ and 47.2 for females and males, respectively).

The Temperature × Frustration interaction also was significant, $F(1, 100) = 7.25$, $p < .01$. The slopes relating temperature to perceived arousal revealed that this interaction resulted from a strong negative relation in the moderate-frustration condition ($b = -1.09$, $p < .01$) and virtually no relation in the low-frustration conditions ($b = .04$, *ns*). None of the other interactions approached significance.

Physiological measures of arousal. At each of the four time periods, the physiological measures were assessed twice to increase accuracy. The averages of the two readings were used in all analyses. These readings were obtained at four different times: baseline (before the participant entered the game room) and three times while in the game room. If the temperature-aggression relation found in previous studies is due (in part) to physiological arousal effects, then we should find differences between the baseline measures and the average of the three measurements taken while the subject was in the game room, as a function of the temperature of the game room. We tested this specific contrast for heart rate and blood pressure. That is, we averaged the heart rate data across the three periods it was measured in the game room (where temperature was manipulated) and subtracted from this average the baseline heart rate. The same was done with blood pressure.

For heart rate, the Sex × Frustration × Temperature regression analyses on these change scores revealed two significant effects. First, there was a main effect of temperature, $F(1, 99) = 4.25$, $p < .05$. The regression line relating temperature to change in heart rate indicated that hotter temperatures produced increases in heart rate, whereas comfortable temperatures resulted in little change (b = .18, a = –13.7). Plugging in relevant values revealed that on average, one could expect a 3.2 beat per minute increase in heart rate at 94°F, whereas at 72°F, the average change was a drop of .8 beats per minute. This is evidence that hot temperatures do increase physiological arousal, at least under some circumstances. Second, there was a main effect because of frustration condition $F(1, 99) = 3.99$, $p < .05$. Persons in the low-frustration condition (M = 3.62) showed a greater increase in heart rate than persons in the moderate-frustration condition (M = 1.39).

Blood pressure was analyzed in the same way except that type of blood pressure (systolic vs. diastolic) was also included as a within-subjects factor. The only significant effects involved the necessary differences between systolic and diastolic blood pressure. None of the temperature or frustration effects approached significance.

In sum, the heart rate data support those theories that explain the temperature-aggression relation via physiological arousal mechanisms. The lack of similar blood pressure effects suggests caution in making broad claims about general arousal in this context, but the blood pressure results may best be understood in terms of thermoregulation.

State hostility. State hostility scores could range from 35 to 175. As predicted, the main effect of temperature was significant, $F(1, 104) = 10.15$, $p < .002$. The slope relating temperature to feelings of hostility (b = .80) indicated that as temperature increased, so did anger and hostility. Thus, at 94°F, the average level of state hostility was 78.9; the average at 72°F was 61.3. This provides strong experimental support for those theories that explain the temperature-aggression relation via affect mechanisms. Figure 2 presents the best fit regression line relating temperature to state hostility.

Hostile cognition. The possible range of scores was 70 to 350. The frustration manipulation had no effect (p > .2). As is frequently found in the aggression literature, there was a significant main effect of sex of participant, $F(1, 102) = 15.63$, $p < .0001$. Males displayed greater hostile cognition than did females (Ms = 177 and 160, respectively).

Of primary interest was the temperature effect. Would a temperature manipulation that took place in a different study, in a different room, with a different experimenter have some impact on cognitive state measures of hostility? The main effect of temperature was indeed significant, $F(1, 102) = 6.07$, $p < .02$. The regression line relating temperature to hostile cognition (b = .91) indicated that as temperatures became more uncomfortably hot, subjects' self-reported traits, beliefs, and attitudes regarding aggression and violence became more hostile. Thus, at 94°F, the average level of hostile cognition was

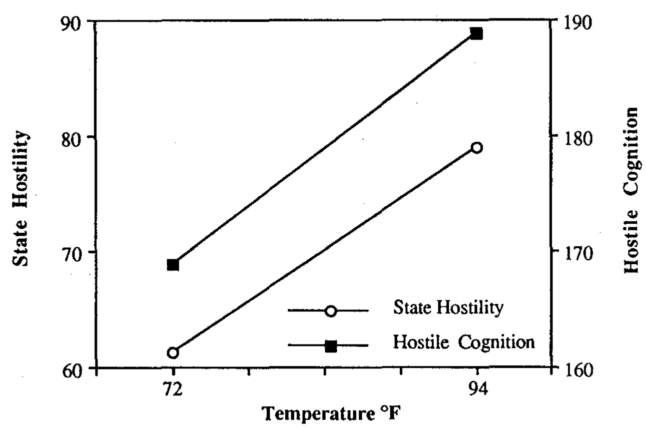

Figure 2 Effects of temperature on state hostility and hostile cognition, Experiment 1, best fit regression lines.

189; the average at 72°F was 169. The regression line for this effect is also presented in Figure 2.

Summary

The results of Experiment 1 suggest that hot temperatures may influence aggression through all three routes that have appeared in various theories. Hot temperatures appeared to increase physiological arousal while decreasing perceptions of arousal. This may be the ideal circumstance for excitation transfer results to occur. If a salient anger-inducing source were present in hot conditions, some of the arousal actually arising from the temperature could be "transferred" to increased perceptions of threat and anger in the primary appraisal stage. Additional work on this route is likely to prove fruitful.

Hot temperatures also increased feelings of hostility, even though there was no reasonable target for such feelings. Similarly, hot temperatures increased reported hostile cognitions. In other words, both of the routes also remain as plausible ways in which hot temperatures could increase aggressive behavior.

One question of interest concerns the directness with which hot temperatures influence affect and cognition. Were hostile cognitions directly primed by the hot temperatures? Alternatively, was the effect of temperature on the hostile cognition measure the result of an indirect effect, via the temperature effect on state hostility? In this paradigm it is impossible to "prove" either possibility. However, to get a further glimpse of the underlying processes, supplementary regression analyses were performed in which the temperature effects on affect and cognition were assessed after statistically controlling for the other. Interestingly, temperature still significantly predicted state hostility even after hostile cognitions were partialed out, $F(1, 102) = 7.62$, $p < .01$. However, temperature did not significantly predict hostile cognition after state hostility was partialed out, $F(1, 102) = 1.68$, $p = .20$. These results do not rule out separate and direct routes from temperature to cognition and affect, but additional work on these routes to affective aggression is needed.

EXPERIMENT 2

The arousal results from Experiment 1 were not entirely clear. Perceived arousal appeared to decrease at hotter temperatures, at least in the moderate-frustration condition. Heart rate showed a small increase in the hotter conditions, both in absolute terms and relative to the slight decrease obtained in comfortable conditions. We decided to attempt to replicate these results in a totally different setting. Furthermore, we decided to provide an additional validity check on our arousal measures by examining the effects of brief exercise. The perceived and the physiological measures should all show significant exercise effects.

Because the temperature/hostility effect is of prime importance, we included state hostility in Experiment 2 as well. The difference in context and procedures between these experiments provides a test of the generalizability of the Experiment 1 findings. Finally, Experiment 2 provided the first test of temperature effects on general positive and negative affect. As noted in the introduction, several major theories of the temperature-aggression relation rely on a temperature-affect relation. What is unclear is the extent to which temperature influences general affective states versus more specific states such as hostility.

Method

DESIGN AND OVERVIEW

The experiment employed a 3 (Temperature) × 3 (Time) repeated measures design. Half of the participants were randomly assigned to either a comfortable or an uncomfortable condition. Within the uncomfortable condition, participants were further randomly assigned to either a warm or a hot condition. The main dependent variables (perceived arousal, physiological arousal, state hostility, positive and negative affect) were assessed before entering the temperature room, immediately after brief exercise in the temperature room, and about 20 minutes after the exercise but while still in the temperature room.

SUBJECTS

A total of 47 students from a large midwestern university participated in the study. The data from 4 students were discarded because of suspicion. The final sample consisted of 23 females and 20 males. Degrees of freedom differed in various analyses because of occasional missing scores. Participants wore short-sleeved shirts to minimize the effects of clothing on the effectiveness of the temperature manipulation. Sessions ranged in size from one to four participants. Each received credit for course requirements in introductory psychology classes. The procedure took approximately 65 minutes to complete.

PROCEDURE

The experiment began in a room set at a comfortable temperature (approximately 72-75°F). Participants were led to believe that the research involved the effect of temperature on physiological measures as related to exercise. After signing the consent form, participants provided background information including age, sex, class, height, weight, and the number of hours of exercise per week. Heart rate and blood pressure were then measured, as in Experiment 1. Finally, several questionnaires were administered. One assessed participants' familiarity with a large set of adjectives. Four dependent measures were derived from the remaining questionnaires. One was an expanded version of the PAS used in Experiment 1. Another was state hostility, as measured in Experiment 1. We also used the revised Positive and Negative Affect Scales (PANAS; Watson, Clark, & Tellegen, 1988). These affect scales were developed to independently assess general feelings of positive and negative affect. Watson et al. have demonstrated good internal reliabilities (alphas from .84 to .90).

Next, the participants were escorted to the temperature room. The average temperature for those in the comfortable condition was 75.4°F (range = 73°F-78°F). The average for the warm condition was 85.2°F (range = 85°F-87°F). The hot condition average was 93.6°F (range = 93°F-95°F). Participants sat at individual cubicles and worked on a questionnaire dealing with their beliefs toward abnormal populations. After 10 minutes, the exercise manipulation took place. Participants exercised one at a time for 1 minute each. During the exercise period, participants stepped up onto a step stool and then back down again as quickly as was comfortable for them. After the exercise period, measures of heart rate, blood pressure, perceived arousal, state hostility, and general affect were taken for the second time.

Participants then returned to the questionnaire concerning beliefs about abnormal populations. After 30 minutes in the temperature room (20 minutes postexercise), measures of heart rate, blood pressure, perceived arousal, state hostility, and general affect were taken for the third and final time. Also administered was a 4-item questionnaire designed to assess suspicions about the true hypothesis. Participants were escorted back to the original comfortable room where they were thoroughly debriefed.

QUESTIONNAIRES

The first questionnaire measured participants' familiarity with and understanding of adjectives used in other scales. Each adjective was rated on "how familiar and understandable" it was, using a scale ranging from 1 = *very slightly or not at all* to 5 = *extremely*. These ratings were used to delete items deemed inappropriate for our subject population.

The second questionnaire was labeled "Current Feelings and Emotions." This questionnaire consisted of 76 feeling and emotion adjectives. Participants were instructed to "indicate to what extent you feel this way right now, that is, at the present moment." They did so using a 5-point rating format (1 = *very slightly or not at all*, 2 = *a little*, 3 = *moderately*, 4 = *quite a bit*, 5 = extremely). Of the adjectives, 31 were intended to be used as a measure of perceived arousal. Of these, 15 were from the PAS in Experiment 1. Although the 15-item PAS proved to be internally consistent in Experiment 1, we added 16 more arousal-related items in an attempt to create the most sensitive measure. Of the 31 arousal items, 12 indicated high levels (e.g., sharp), whereas 19 indicated a lack of arousal (e.g., sluggish). Also included in the set of 76 items were the PANAS items and the MAACL items that were part of the state hostility measure. The final questionnaire was the State Anger Scale (Spielberger et al., 1983). It also was used as a part of the state hostility measure, as in Experiment 1.

Results

PRELIMINARY ANALYSES

Temperature control. Within the three temperature conditions, actual temperatures varied somewhat, but there was no overlap. As originally planned, we again used regression analyses with temperature as a continuous factor.

The PAS construction. The familiarity ratings were examined to see if any of the 31 PAS items were unfamiliar to our subject population. Items were eliminated if the mean response was less than 4 (indicating moderate or less familiarity) and 15% or more of the respondents rated the item with a 1 or 2, which reflects little to no familiarity. Five items from the PAS were dropped on the basis of this analysis. None of the deleted items were from the 15 PAS items used in Experiment 1.

Item-total correlations, correlations between positive and negative arousal subscales, and Cronbach's alpha were also examined. Two items were dropped because of low item-total correlations. The expanded PAS thus contained 24 items: 10 were positive arousal items (e.g., alert); 14 were negative arousal items (e.g., sleepy).

The positive and negative subscales were strongly correlated at each of the three times of measurement (.48, .55, .50, respectively). Thus they were combined (as in Experiment 1) into one overall PAS. The internal reliability was quite high (Cronbach's alpha = .94).[3] The complete listing of PAS items appears in the appendix.

Other rating scale measures. Our state hostility measure, derived from the MAACL Hostility items and the State Anger Scale (as in Experiment 1) again displayed adequate internal reliability, alpha = .81. The positive and negative affect measures also had acceptable internal reliabilities, alphas = .95 and .61, respectively, although the latter was a bit low. This apparently resulted from the relatively low level of endorsement of the negative affect items.

MAIN ANALYSES

Two different sets of analyses were conducted on each dependent variable. One focused on the effects of exercise, whereas the other focused on temperature effects. The most precise tests of pure exercise effects involve examining data from only those subjects in the comfortable temperature condition.[4] In these analyses, sex was included as a categorical between-subjects factor, and time (all three assessments) was included as a repeated measures factor.

The most precise tests of temperature effects involve examining shifts in subjects' scores across time (Time 1 to Time 3) as a function of temperature and sex.

Perceived arousal. Scores could range from 24 (lowest arousal) to 120 (highest arousal). One reason for the exercise manipulation was to further examine the validity of the PAS. For subjects in the comfortable condition, we expected the PAS scores to increase from Time 1 (taken in the starting room) to Time 2 (taken in the temperature room immediately after exercising), and to decrease from Time 2 to Time 3. This is exactly what happened, as revealed by the means in Table 1. This main effect of time was significant, $F(2, 42) = 6.66$, $p < .004$. Thus the PAS was sensitive to changes in perceived arousal created by brief exercise.

The effect of temperature is most precisely tested by comparing Time 1 to Time 3 shifts as a function of temperature. Recall that at Time 3, participants had been in the temperature room for 30 minutes. As anticipated, the interaction between time and temperature was significant, $F(1, 37) = 10.39$, $p < .003$. A simple regression analysis of the change scores (Time 3 – Time 1) as a function of temperature (which is exactly what the Time × Temperature interaction examines) revealed that perceived arousal decreased as temperature increased ($b = -.75$). This effect is illustrated in Figure 3.

Physiological measures of arousal. We first examined the effects of exercise on diastolic and systolic blood pressure in a repeated measures analysis with type (diastolic

TABLE 1: Effects of Brief Exercise on Perceived Arousal, Physiological Arousal, State Hostility, Negative Affect, and Positive Affect, Means for Experiment 2, Comfortable Condition Only

	Time of Assessment		
Dependent Variable	*Time 1 (Baseline)*	*Time 2 (Postexercise)*	*Time 3 (Session End)*
Perceived arousal[1]			
(n = 23)	86.1_a	94.1_b	92.0_b
Physiological arousal			
Diastolic blood pressure			
(n = 24)	71.1_a	77.6_b	72.9_{ab}
Systolic blood pressure			
(n = 24)	121.2_a	133.2_b	118.7_a
Heart rate (n = 20)	78.5_a	100.1_b	74.6_a
State hostility[2] (n = 23)	84.0_a	94.5_b	86.2_a
Positive affect[3] (n = 24)	32.2_a	33.6_a	31.2_a
Negative affect[3] (n = 24)	12.2_{ab}	12.8_a	11.4_b

NOTE: Means within a row that do not share a subscript differ at $p < .05$.
1. Scores could range from 24 (lowest arousal) to 120 (highest arousal).
2. Scores could range from 35 (lowest hostility) to 175 (highest hostility).
3. Positive and negative affect scores could range from 10 to 50.

vs. systolic) and time (Time 1, Time 2, Time 3) as the repeated factors. Once again, only subjects in the comfortable condition were used for this analysis of exercise effects.

Of course, there was a huge effect of type of blood pressure, $F(1, 22) = 562$, $p < .0001$. There was also a main effect of sex, with males having higher pressures than females, $F(1, 22) = 6.41$, $p < .02$. These main effects were qualified by a Sex × Type interaction, $F(1, 22) = 9.52$, $p < .006$. Males and females differed in systolic pressure (*Ms* = 131.0 and 117.7, respectively), but they did not differ in diastolic pressure (*Ms* = 73.9 and 73.8, respectively).

Of more immediate interest was the effect of exercise on blood pressure. If our measures are sensitive, we should see an increase from Time 1 (baseline) to Time 2 (immediately after exercising) and then a decrease at Time 3. As expected, the main effect of time was exactly of this form (see Table 1) and was significant, $F(2, 44) = 12.81$, $p < .0001$. The Time × Type interaction also was significant, $F(2, 44) = 6.61$, $p < .004$. Investigation of the time effects for each type separately revealed that both diastolic and systolic pressures showed exactly the same pattern (*p*s < .01). However, the effect was larger for systolic pressure.

The effect of temperature on blood pressure, tested by examining Time 1 to Time 3 shifts as a function of temperature, revealed that temperature had no impact ($p > .4$). In sum, the exercise effects on blood pressure demonstrate that our measurements were sensitive enough to pick up sex and exercise effects but yielded no effects of temperature. As noted earlier, thermoregulation processes include vasodilation as a means of heat

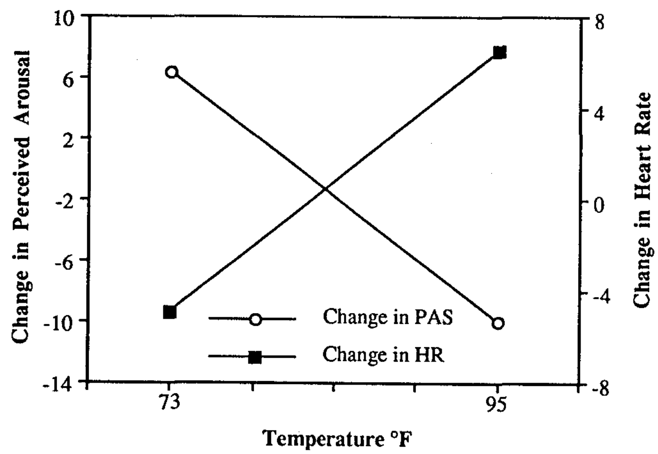

Figure 3 **Effects of temperature on perceived arousal and heart rate, Experiment 2, best fit regression lines.**

transfer. This could easily offset or even override increases in blood pressure because of general arousal. For these reasons, heart rate may provide a better test of physiological arousal effects of heat.

Like blood pressure, heart rate was affected by exercise, $F(2, 36) = 20.63$, $p < .0001$. As revealed in Table 1, subjects in the comfortable temperature condition had heart rates that increased with exercise and then decreased with rest.

Heart rate was also influenced by temperature, replicating the results of Experiment 1. The interaction between time (Time 1 vs. Time 3) and temperature was significant, $F(1, 36) = 6.67$, $p < .02$. Hotter temperatures led to a relative increase in heart rate ($b = .52$), as illustrated in Figure 3. Thus hot temperatures may influence aggression-related appraisals and behaviors through excitation transfer processes.

State hostility. Feelings of hostility were significantly affected by exercise, $F(2, 42) = 35.83$, $p < .0001$. The means, in Table 1, revealed a pattern similar to those found with the various measures of perceived and physiological arousal. Hostility increased from baseline to postexercise, then decreased at the session's end. However, hostility did not return completely to baseline level. That is, hostility was marginally higher at Time 3 than at Time 1, $F(1, 21) = 3.60$, $p < .07$.

The critical test of interest, of course, concerns temperature effects. As expected, the Time (Time 1 vs. Time 3) × Temperature interaction yielded a significant effect, $F(1, 34) = 7.59$, $p < .01$. As in Experiment 1, hotter temperatures led to an increase in state hostility ($b = .41$), illustrated in Figure 4. This supports the supposition that hot temperatures do prime specific hostility-related feelings.

General affect. The positive and negative affect scores could range from 10 to 50. They were only weakly corre-

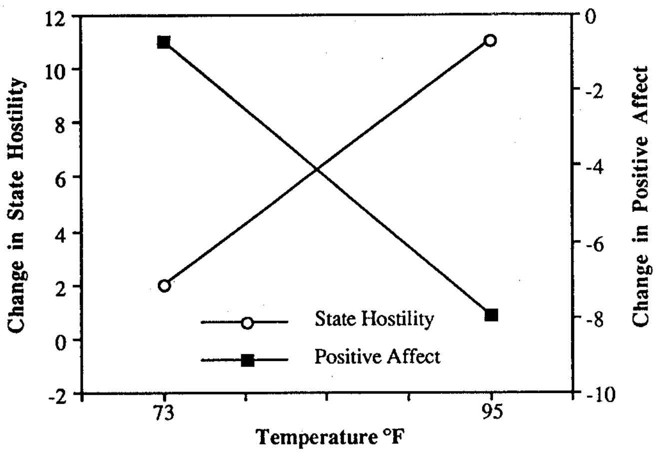

Figure 4 Effects of temperature on state hostility and positive affect, Experiment 2, best fit regression lines.

lated at each of the three times of administration (–.25, –.23, and –.19). This is a common finding and was expected. Thus they were analyzed separately.

For negative affect, there were no significant effects of time, sex, or temperature, $ps > .1$. The overall average in this study was 12.3, barely above the minimum of 10, indicating little endorsement of any of the items. Thus, although the lack of a temperature effect suggests that hot temperature does not automatically prime general negative affect, an alternative explanation is that the PANAS negative affect scale is not sensitive enough.

General positive affect was not significantly influenced by time or sex, $ps > .1$. However, the Time (Time 1 vs. Time 3) × Temperature analysis yielded a significant interaction, $F(1, 39) = 5.92$, $p < .02$. Hot temperatures led to decreased general positive affect ($b = -.33$), as illustrated in Figure 4.[5]

General Discussion

STATE HOSTILITY

The state hostility results supported the predictions from several theoretical perspectives on how hot temperatures might increase aggression. Hotter temperatures increased feelings of hostility in both experiments. The effect occurred in both low- and moderate-frustration conditions. It occurred in contexts devoid of potential targets of hostility. What little work that has been done in the past on temperature and affect involved interpersonal attraction paradigms. Our cognitive performance paradigm and our exercise paradigm presumedly removed many of the demand characteristics present in previous studies, which put subjects in uncomfortable rooms and asked them how much they liked a target stranger. Our careful assessment of suspicion lends further credence to the obtained state hostility effects. In broad terms, our results converge with the suggestions of past scholars that hot temperatures may influence aggression through the specific negative affect of hostility or anger.

HOSTILE COGNITION

The hostile cognition results of Experiment 1 provide an additional route for heat effects on aggression. Hostile cognition was assessed in a different room, by a different experimenter, under the guise of a separate experiment. Our postexperimental debriefing revealed that subjects did not connect the temperature manipulations with the hostile cognition measures. Yet the cognitive state measure yielded a consistent temperature effect. Those in hotter conditions reported that aggressive behaviors were more characteristic of them and reported more hostile attitudes and beliefs.

AROUSAL

Both experiments found that hot temperatures increased heart rate, decreased perceived arousal, and did not change blood pressure. Although excitation transfer theory is not entirely clear on the roles of perceived and physiological arousal, one might expect maximum excitation transfer when physiological arousal has increased while perceived arousal has decreased. That is, hot temperatures may set the stage for excitation transfer to occur. Thus this third route through which hot temperatures may increase aggression, suggested by our model in Figure 1, has survived these initial tests. Work more specifically directed at examining excitation transfer effects of hot temperatures would be valuable.

GENERAL AFFECT

Negative affect was not reliably influenced by temperature in Experiment 2. This finding, in conjunction with the repeated finding of temperature effects on feelings of hostility, suggests that affective formulations in the temperature-aggression area might best conceive of negative affect in more specific terms. Of course, one cannot conclude on the basis of this work that only hostility-related negative affect is influenced by uncomfortable temperatures. But the specificity issue deserves additional attention.

CONCLUSIONS

The major point of our results concerns the usefulness of the general theoretical model in Figure 1. In addition to all the work that nicely fits this model from many types of aggression studies (see Berkowitz, 1990; Geen, 1990), it provides a useful framework for understanding and investigating temperature effects. The model makes clear predictions concerning a host of aggression-related variables that should be affected by temperature and by other situational and subject variables. The present experiments clearly demonstrated that hot temperatures increase state hostility and hostile cognition, while simultaneously setting the stage for excitation transfer effects.

It is also clear that more detailed studies are needed to test specific theories of the temperature-aggression relation, and to test the theoretical model more generally. For instance, studies investigating temperature effects on primary appraisal and on actual aggressive behavior would seem the logical next steps in this line of work. In addition, the effects of uncomfortably cold temperatures need to be investigated. Further work specifically testing excitation transfer is needed. Although the empirical investigation of the temperature-aggression hypothesis has a long history, we think that the most important advances are yet to come. We also think that casting these advances within a broader theory of affective aggression is important both to the understanding of temperature effects and, more important, to the understanding of affective aggression in general.

APPENDIX
The Perceived Arousal Scale

Instructions and Items Used in Experiment 1 (15 items total):

Perceived State of Arousal

Different people react very differently to the same situations. Please indicate how you currently feel by rating how well each of the following words describes how you feel. Use the following 7-point rating scale. Write the number corresponding to your rating on the blank line next to each word.

Does Not Describe How I Feel at All — *Accurately Describes How I Feel*

1 2 3 4 5 6 7

Active	____	Depressed*	____	Drowsy*	____	Dull*	____
Energetic	____	Excited	____	Exhausted*	____	Forceful	____
Lively	____	Sharp	____	Sluggish*	____	Tired*	____
Vigorous	____	Weak*	____	Weary*	____		

Instructions and Additional Items Used in Experiment 2 (24 items total):

Perceived State of Arousal

Different people react very differently to the same situations. Indicate to what extent you feel this way right now, that is, at the present moment. Use the following 5-point rating scale. Write the number corresponding to your rating on the blank line next to each word.

Very Slightly or Not At All	*A Little*	*Moderately*	*Quite a Bit*	*Extremely*
1	*2*	*3*	*4*	*5*

Alert	____	Aroused	____	Fatigued*	____	Inactive*	____
Powerful	____	Quiet*	____	Sleepy*	____	Slow*	____
Worn-out*	____						

NOTE: *Item was reverse scored.

NOTES

1. Excitation transfer theory is sometimes referred to as Zillmann's misattribution of arousal theory, because the residual excitation is presumedly misattributed to a later presented salient source.

2. There has been considerable debate on whether the relation between temperature and aggressive behavior is linear or curvilinear. Note that this debate is irrelevant to studies of aggression-related affects or cognitions, because the major theory behind the curvilinear predictions for behavior predicts linear ones for affect and cognitions. Nonetheless, we felt it important to explore the possibility of curvilinear effects.

3. Reliabilities are from the Time 3 measurements. Comparable reliabilities were obtained at the other times.

4. We thank an anonymous reviewer for pointing this out.

5. As one helpful reviewer pointed out, positive affect as measured by the PANAS assesses both positivity and arousal. Indeed, three positive affect items are also on the PAS. Therefore, we also analyzed positive affect using only the seven nonarousal items. The results were similar, but the temperature effect as assessed by the interaction became nonsignificant, $F(1, 40) = 3.65$, $p < .07$.

REFERENCES

Anderson, C. A. (1989). Temperature and aggression: Ubiquitous effects of heat on occurrence of human violence. *Psychological Bulletin, 106,* 74-96.

Anderson, C. A., & DeNeve, K. M. (1992). Temperature, aggression, and the negative affect escape model. *Psychological Bulletin, 111,* 347-351.

Anderson, C. A., & Ford, C. M. (1986). Affect of the game player: Short-term effects of highly and mildly aggressive video games. *Personality and Social Psychology Bulletin, 12,* 390-402.

Aschaffenburg, G. (1913). *Crime and its repression.* Boston: Little, Brown. (Original work published 1903)

Baron, R. A. (1979). Aggression and heat: The "long hot summer" revisited. In A. Baum, J. E. Singer, & S. Valins (Eds.), *Advances in environmental psychology* (pp. 57-84). Hillsdale, NJ: Lawrence Erlbaum.

Baron, R. A., & Bell, P. A. (1975). Aggression and heat: Mediating effects of prior provocation and exposure to an aggressive model. *Journal of Personality and Social Psychology, 31,* 825-832.

Baron, R. A., & Bell, P. A. (1976). Aggression and heat: The influence of ambient temperature, negative affect, and a cooling drink on physical aggression. *Journal of Personality and Social Psychology, 33,* 245-255.

Bell, P. A. (1981). Physiological, comfort, performance, and social effects of heat stress. *Journal of Social Issues, 37,* 71-94.

Bell, P. A., & Baron, R. A. (1974). Environmental influences on attraction: Effects of heat, attitude similarity, and personal evaluations. *Bulletin of the Psychonomic Society, 4,* 479-481.

Bell, P. A., Garnand, D. B., & Heath, D. (1984). Effects of ambient temperature and seating arrangement on personal and environmental evaluations. *Journal of General Psychology, 110,* 197-200.

Berkowitz, L. (1990). On the formation and regulation of anger and aggression: A cognitive-neoassociationistic analysis. *American Psychologist, 45,* 494-503.

Blascovich, J., & Kelsey, R. M. (1990). Using electrodermal and cardiovascular measures of arousal in social psychological research. In C. Hendrick & M. Clark (Eds.), *Research in personality and social psychology* (pp. 45-73). Newbury Park, CA: Sage.

Burt, M. R. (1980). Cultural myths and support for rape. *Journal of Personality and Social Psychology, 38,* 217-230.

Buss, A. H., & Durkee, A. (1957). An inventory for assessing different kinds of hostility. *Journal of Consulting Psychology, 21,* 343-349.

Cacioppo, J. T., & Petty, R. E. (1986). Social processes. In M. Coles, E. Donchin, & S. Porges (Eds.), *Psychophysiology: Systems, processes, and applications.* New York: Guilford.

Cantor, J. R., Zillmann, D., & Bryant, J. (1975). Enhancement of experienced sexual arousal in response to erotic stimuli through misattribution of unrelated residual excitation. *Journal of Personality and Social Psychology, 32,* 69-75.

Dexter, E. G. (1899). Conduct and the weather. *Psychological Monographs, 11*(10), 1-103.

Geen, R. G. (1990). *Human aggression.* Pacific Grove, CA: Brooks/Cole.

Griffitt, W. (1970). Environmental effects on interpersonal affective behavior: Ambient effective temperature and attraction. *Journal of Personality and Social Psychology, 15,* 240-244.

Griffitt, W., & Veitch, R. (1971). Hot and crowded: Influences of population density and temperature on interpersonal affective behavior. *Journal of Personality and Social Psychology, 17,* 92-98.

Kruglanski, A. W. (1989). *Lay epistemics and human knowledge: Cognitive and motivational bases.* New York: Plenum.

Lombroso, C. (1911). *Crime: Its causes and remedies.* Boston: Little, Brown. (Original work published 1899)

Rotton, J. (1985, August). *Pedestrian movement in warm and cool settings.* Paper presented at the 95th annual convention of the American Psychological Association, Los Angeles.

Rotton, J., Shats, M., & Standers, R. (1990). Temperature and pedestrian tempo: Walking without awareness. *Environment and Behavior, 22,* 650-674.

Rule, B. G., & Nesdale, A. R. (1976). Environmental stressors, emotional arousal, and aggression. In I. Sarason & C. Spielberger (Eds.), *Stress and anxiety* (Vol. 3, pp. 87-104). New York: Halstead.

Rule, B. G., Taylor, B. R., & Dobbs, A. R. (1987). Priming effects of heat on aggressive thoughts. *Social Cognition, 5,* 131-143.

Spielberger, C. D., Jacobs, G., Russell, S., & Crane, R. S. (1983). Assessment of anger: The state-trait anger scale. In J. Butcher & C. Spielberger (Eds.), *Advances in personality assessment* (Vol. 2, pp. 159-187). Hillsdale, NJ: Lawrence Erlbaum.

Velicer, W. F., Huckel, L., & Hansen, C. E. (1989). A measurement model for measuring attitudes toward violence. *Personality and Social Psychology Bulletin, 15,* 349-364.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology, 54,* 1063-1070.

Zillmann, D. (1971). Excitation transfer in communication-mediated aggressive behavior. *Journal of Experimental Social Psychology, 7,* 419-434.

Zillmann, D. (1983). Arousal and aggression. In R. Geen & E. Donnerstein (Eds.), *Aggression: Theoretical and empirical reviews* (Vol. 1, pp. 75-102). New York: Academic Press.

Zuckerman, M., Lubin, B., Vogel, L., & Valerius, E. (1964). Measurement of experimentally induced affects. *Journal of Consulting and Clinical Psychology, 28,* 418-425.

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