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AGGRESSION AND VIOLENCE IN THE INNER CITY

Effects of Environment via Mental Fatigue

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ABSTRACT: S. Kaplan suggested that one outcome of mental fatigue may be an increased propensity for outbursts of anger and even violence. If so, contact with nature, which appears to mitigate mental fatigue, may reduce aggression and violence. This study investigated that possibility in a setting and population with relatively high rates of aggression: inner-city urban public housing residents. Levels of aggression were compared for 145 urban public housing residents randomly assigned to buildings with varying levels of nearby nature (trees and grass). Attentional functioning was assessed as an index of mental fatigue. Residents living in relatively barren buildings reported more aggression and violence than did their counterparts in greener buildings. Moreover, levels of mental fatigue were higher in barren buildings, and aggression accompanied mental fatigue. Tests for the proposed mechanism and for alternative mechanisms indicated that the relationship between nearby nature and aggression was fully mediated through attentional functioning.

The power of the physical environment to influence human aggression is well established. Crowding, high temperatures, and noise have all been linked to aggression and violence (Baker, 1984; Baum & Koman, 1976; Donnerstein & Wilson, 1976; Rule, Taylor, & Dobbs, 1987). Each of these features of the physical environment has been associated with heightened levels of aggression; are there features of the physical environment that work to diminish levels of aggression and violence? This study examines whether

natural elements such as trees and grass can decrease aggression. In addition, it tests a potential mechanism by which natural features—and by extension other environmental features—may affect aggression. In doing so, it suggests a new role for environment and behavior research in an important public policy domain—addressing aggression and violence in inner cities—and contributes possible new insight into the psychological factors underlying human aggression.

There are hints in the literature that exposure to nearby nature, for instance, a garden or a grassy area with trees, may reduce aggression. For instance, violent assaults by Alzheimer patients were compared during two consecutive summers in five long-term care facilities, two in which exterior gardens were installed and three without gardens (Mooney & Nicell, 1992). In Alzheimer patients, increases in the number of aggressive assaults each year are typical as a consequence of the progressive deterioration of cognitive processes; and indeed, in the facilities without gardens, the incidence of violent assaults increased dramatically. By contrast, in the other facilities, the incidence of violent assaults stayed the same or decreased slightly after gardens were installed. More recently in another study, some subsets of prison inmates reported less hostility after participating in a gardening project than before, although these findings were not consistent across different analyses (Rice & Remy, 1998).

Why might we expect the findings from these two studies to reflect a more general, systematic phenomenon? By what mechanism might exposure to nearby nature leave individuals in a less aggressive state? Here, we review

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theory and evidence suggesting first that natural settings assist in recovery from mental fatigue and second that aggression may increase with mental fatigue and decrease with its recovery. We then present an analysis suggesting that residents of disadvantaged inner-city neighborhoods may be subject to chronic mental fatigue. Finally, we test the possibility that, in an urban public housing community, the presence of trees and grass lowers the incidence of aggressive and violent behavior among residents living nearby.

NATURE AND MENTAL FATIGUE

Attention restoration theory (S. Kaplan, 1995) proposes that exposure to nature reduces mental fatigue, or more precisely, directed attention fatigue. S. Kaplan (1995) noted that many settings, stimuli, and tasks in modern life draw on the capacity to deliberately direct attention or pay attention. The information-processing demands of everyday life—traffic, phones, conversations, problems at work, and complex decisions—all take their toll, resulting in mental fatigue, a state characterized by inattentiveness, irritability, and impulsivity. In contrast, natural settings and stimuli such as landscapes and animals seem to effortlessly engage our attention, allowing us to attend without paying attention. For this and a number of other reasons, S. Kaplan suggested, contact with nature provides a respite from deliberately directing one's attention.

Indeed, there is growing empirical evidence of the attentionally restorative effects of natural settings. Evidence of cognitively rejuvenating effects comes from a variety of "natural" settings, including wilderness areas (Hartig, Mang, & Evans, 1991; R. Kaplan, 1984), prairies (Miles, Sullivan, & Kuo, 1998), community parks (Canin, 1991; Cimprich, 1993), views of nature through windows (Ovitt, 1996; Tennessen & Cimprich, 1995), and even rooms with interior plants (Lohr, Pearson-Mims, & Goodwin, 1996). Moreover, these studies have demonstrated links between contact with nature and more effective attentional functioning in a variety of populations—AIDS caregivers, cancer patients, college students, prairie restoration volunteers, participants in a wilderness program, and employees of large organizations.

MENTAL FATIGUE AND AGGRESSION

If contact with nature is attentionally restorative, how then might attentional restoration mitigate aggression? S. Kaplan (1987) suggested that one of the costs of mental fatigue might be a heightened propensity for "outbursts of anger and potentially . . . violence" (p. 57). The following analysis

shows how each of three symptoms of mental fatigue might contribute to aggression.

First, mental fatigue may contribute to aggression because of its effects on cognitive processing. A common theme in some recent theories of aggression is that information processing plays a central role in managing social situations, especially potential conflicts (e.g., Crick & Dodge, 1994; Dodge & Crick, 1990; Dodge & Schwartz, 1997; Martinko & Zellars, 1998). For example, Dodge and Crick (1990) proposed that a child's behavioral response to a social stimulus is a function of the following five steps of information processing: encoding of social cues, interpretation of social cues, response search, response evaluation, and enactment. The proposal here is that in problematic social situations, relatively automatic, effortless cognitive processing (e.g., "Bob took my computer station!") is more likely to generate conflict-escalating behavior than is more reasoned, effortful, reflective processing (e.g., "Hmm . . . did I leave any clues that I was working there?"). As the individual's willingness and ability to engage in more reflective, effortful processing decreases with mental fatigue, social behavior is likely to become increasingly thoughtless, tactless, and unstrategic, allowing conflicts to spiral out of control (see Rubin, Bream, & Rose-Krasnor, 1991, for a similar proposal with respect to children's social problem solving).

There is some evidence to suggest that deficits in effortful processing are indeed associated with aggression. In school settings, deficits in effortful processing are likely to manifest in inattentiveness, and inattentiveness has been closely tied to aggression in both children (Stewart, 1985) and adolescents (Scholte, van Aken, & van Lieshout, 1997). Indeed, the tie between attention deficits and hyperactivity on one hand and conduct problems and aggression on the other has been so strong that there has been some debate as to whether these disorders are distinct (see Hinshaw, 1987, for a meta-analysis indicating that these disorders are distinct although correlated). Conversely, Rabiner, Lenhart, and Lochman (1990) found that when aggressive children were encouraged to be more reflective in their responses to problematic social situations, their generation of conflict-escalating responses dropped to the same levels as their nonaggressive, nonrejected peers. Thus, it seems plausible that the deficits in effortful processing that are symptomatic of mental fatigue may contribute to aggression.

Mental fatigue may also contribute to aggression because of its effects on emotion—specifically, heightened irritability. Irritability appears to be a frequent side effect of mentally fatiguing tasks, such as the vigilance tasks involved in air traffic control (Thackray, Bailey, & Touchstone, 1979; Warm & Dember, 1986). Not surprisingly, irritability is linked with aggression in numerous studies (e.g., Caprara & Renzi, 1981; Coccaro, Bergeman,

Kavoussi, & Seroczynski, 1997; Kant, Smith-Seemiller, & Zeiler, 1998; Kavoussi & Coccaro, 1998; Stanford, Greve, & Dickens, 1995). Irritable individuals are prone to aggression when faced with frustration (Caprara & Renzi, 1981), and pharmacological treatments that reduce aggression also reduce irritability (Kant et al., 1998; Kavoussi & Coccaro, 1998). Thus, it seems plausible that the irritability symptomatic of mental fatigue might contribute to aggression.

Finally, mental fatigue may also contribute to aggression because of its effects on behavior—specifically, decreased control over impulses. S. Kaplan (1987) noted that one of the hallmarks of mental fatigue is a difficulty inhibiting behavioral impulses. Impulsivity in turn is associated with aggression and violence in a variety of populations (for reviews, see Brady, Myrick, & McElroy, 1998; Markovitz, 1995; Tuinier, Verhoeven, & Van Praag, 1996). Violent parolees are more impulsive than nonviolent parolees (Cherek, Moeller, Dougherty, & Rhoades, 1997), maritally violent men are more impulsive than maritally nonviolent men (Barnett & Hamberger, 1992), and among depressed males, impulsive individuals are more likely to be aggressive than nonimpulsive individuals (Hynan & Grush, 1986). Not surprisingly, then, Luengo and colleagues (Luengo, Carrillo-de-la-Pena, Otero, & Romero, 1994) found in their 1-year longitudinal study that present impulsivity ratings predict future antisocial behavior, including aggression.

In sum, each of these factors—impairments in effortful cognitive processing, irritability, and impulsivity—has been independently implicated in aggression. To the extent that mental fatigue combines these three factors, mental fatigue seems likely to contribute substantially to aggression.

INNER CITIES AND CHRONIC MENTAL FATIGUE

Poor, inner-city neighborhoods may be an especially promising context in which to study the effects of nature and attentional restoration on aggression. As the following analysis, drawn from Kuo (1992), suggests, the attentional demands associated with poverty and the inner-city environment are likely to place this population at special risk for chronic mental fatigue and fatigue-related aggression. As a consequence, residents of poor, inner-city neighborhoods may have a special need for the mental respite provided by nearby nature.

The attentional demands of poverty are many and unremitting. For the poor, even basic concerns such as rent, utilities, and food are ongoing challenges that require effortful problem solving and reasoning. Added to these are the attentional challenges posed by major life events. Poverty brings with it a greater susceptibility and vulnerability to drastic life changes.

Underinsured and having no financial cushion against setbacks, even a minor temporary trauma such as a child's illness can have far-reaching effects, eventually necessitating major readjustments in life, family, and work domains. Making these adjustments requires sustained, high levels of mental functioning.

Moreover, the environmental characteristics of inner-city neighborhoods place additional demands on attention. First and foremost, the ever-present possibility of crime or violence places high demands on attention (see Cohen & Spacapan, 1978, for an analysis of the attentional demands imposed by unpredictable stressors). Danger requires individuals to be vigilant for signs of impending trouble, to continuously consider possible responses to new situations, and to consider the ramifications of those responses. Second, the home environment may place further demands on attention; lack of adequate space and facilities makes purposive functioning more effortful as more problem solving is required to accomplish goals in unsupportive or inadequate settings. Problem solving may be made all the more fatiguing by the lack of quiet, safe settings in which to think. And finally, for the many inner-city residents who lack natural settings in their everyday environment (nearby parks, views to green spaces, and gardens), recovery from mental fatigue may be especially rare.

Over time, the ongoing and acute attentional demands of poverty, in combination with the mentally fatiguing characteristics of the inner-city environment, seem likely to yield chronic high levels of mental fatigue. Thus, among inner-city inhabitants lacking ready access to attentionally restorative settings, we might expect chronic high levels of mental fatigue and a heightened propensity for aggressive behavior. Conversely, among residents with ready access to nature, we might expect comparatively low levels of mental fatigue and aggression.

Two questions are central to this study. First, does nearby nature reduce aggression and violence? And second, if so, is this effect mediated via attentional restoration? To examine these questions, structured interviews and attentional tests were conducted with urban public housing residents. Because official adult residents are predominately single mothers, the structured interviews focused on intrafamily aggression and violence rather than other forms of violence. Attentional performance and self-reports of aggression were then compared for residents living in buildings with relatively high versus relatively low levels of nearby nature, and mediation tests were used to examine whether attentional restoration might account for a relationship between nature and aggression.

To explore possible alternative accounts for a nature-aggression relationship, a number of additional tests were conducted. A test for spuriousness

(Evans & Lepore, 1997) was conducted to guard against alternative accounts in general. In addition, the following three particular alternative accounts were given specific attention: (a) Positive mood, (b) stress recovery, and (c) social support were each identified as theoretically plausible explanations for a link between nature and reduced aggression. Positive mood has been linked directly with contact with nature (Hull & Michael, 1995), and it seems plausible that positive moods could reduce the propensity for aggression (Pihl & Zacchia, 1986, tested this notion but found no evidence for it). Similarly, stress (or more precisely, recovery from stress) has been linked directly with contact with nature (Ulrich et al., 1991), and stress also appears to contribute to aggression (Bolger, Thomas, & Eckenrode, 1997; Chang, 1994). And finally, there is some indication that neighborhood social ties and support networks are stronger around greener neighborhood spaces (Kuo, Sullivan, Coley, & Brunson, 1998; Kweon, Sullivan, & Wiley, 1998); in turn, child abuse is less prevalent among parents who have social support (Garbarino & Sherman, 1980; Roth, 1986).

METHOD

THE SITE: A NATURAL EXPERIMENT ON THE EFFECTS OF NEARBY NATURE

A number of methodological criteria were employed in the selection of a site for this research. Robert Taylor Homes (RTH) in Chicago was rare in that it simultaneously met each of these criteria.

First, although the amount of vegetation outside the buildings at RTH varies considerably from building to building, other environmental features are held remarkably constant from one building to another. Because the buildings are architecturally identical, at RTH, building size, building layout, building facilities, architectural detail, and the number of residential units per building are held constant (see Figure 1). Moreover, because the buildings are placed in single file along a 3-mile corridor, the features of the surrounding landscape are similar from one building to another. Each building is bordered on the west by an interstate highway and railroad tracks and bordered on the east by a six-lane municipal thoroughfare and wide sidewalk.

Second, public housing policies result in de facto random assignment of residents with respect to levels of nearby nature at RTH. Although housing applicants to the Chicago Housing Authority can specify their choice of development (e.g., RTH vs. some other development), they have little choice



Figure 1: Attrition Has Left Some Buildings Surrounded by Only Concrete and Asphalt and Others With Pockets of Green

of where they will be assigned within a development (i.e., this apartment vs. another apartment within RTH).¹ Moreover, the scale of the Chicago Housing Authority precludes the placement of “better” (e.g., more responsible and less aggressive) residents in “better” (e.g., greener) locations. Clerks in a central office handle all assignments of residents to apartments for 40,700 units in 1,479 buildings across 17 developments throughout the city. They generally have never met or seen the applicants for housing and most likely have never set foot in most of the Housing Authority’s developments. It is implausible that anyone could remember the characteristics of so many buildings, let alone take them into account in assigning apartments.

Third, residents at RTH have little role in the landscaping outside their building. When RTH was originally built in the 1960s, trees and grass were planted around each of the 28 high-rise buildings. Over time, the majority of these green spaces have been paved in an effort to keep dust down and maintenance costs low; this paving has killed many of the original trees, leaving some buildings with completely barren common spaces, others with a few scattered trees, and still others with leftover pockets of green. Ongoing landscape maintenance at RTH is handled entirely by a small landscaping crew serving all of the developments managed by the Chicago Housing Authority; residents are not involved in maintenance, and funds are inadequate to fulfill special requests from residents. Thus, a relationship between greenness of common spaces and aggression in this setting cannot be explained by a process in which especially effective or cooperative residents have made their surroundings greener.

In sum, RTH constitutes a naturally occurring experiment on the effects of residential vegetation, with random assignment of residents to vegetation conditions, no control of residents over levels of vegetation, and a host of environmental variables held constant. An additional methodologically desirable feature of RTH for this study is that the residents are strikingly homogeneous with respect to many of the individual characteristics that might be expected to affect aggression—income, education, life circumstances, and perhaps most important, economic opportunities.

PROCEDURE, PARTICIPANTS, AND DESIGN

To maximize participants’ ease in responding, interviewers were selected to be as similar to interviewees as possible. Three African American female residents of RTH were hired and trained to conduct the recruitment, interviewing, and testing for this research. All three were longtime residents of RTH (19 years or more) residing in buildings outside the study sample. Thus,

interviewers were matched to interviewees not only in major demographic characteristics such as race, gender, and socioeconomic status but also in life circumstances, background, and more subtle social cues such as patterns of speech and dress.

In preparation for interviewing and testing, interviewers completed extensive training (50 hours of general training in interview methods, 12 hours learning the specific interview measures used, and 14 hours of supervised and unsupervised practice in performing practice interviews). In addition, an on-site research supervisor met regularly with the interviewers to review procedures and address any difficulties or questions. Interviewers did not interview individuals with whom they were previously familiar, and interviewers were counterbalanced for nature condition.

Recruitment was conducted door to door in buildings spanning the range of vegetation of RTH. Sampling was restricted to 18 buildings—buildings adjacent to parks, police stations, and other relatively unique features were excluded to minimize effects of extraneous factors on residents' access to nearby nature. Within buildings, sampling was restricted to apartments on Floors 2 through 4, where residents had maximal physical and visual access to the trees outside their building (there are no residences on the first floor).

Recruitment criteria included not only environmental factors but also resident characteristics. Women heads of household younger than the age of 65 were invited to participate in a University of Illinois study about life at RTH. Recruitment focused on women because official adult residents in urban public housing are overwhelmingly female—80% in RTH (Chicago Housing Authority, 1995).² Participants were told that they could refuse to answer any question and could stop the interview at any time and that they would receive \$10 on completion of the interview.

Of the 158 qualified residents invited to participate, 92% chose to participate, yielding a final sample of 145 residents, 69 with relatively low levels of nearby nature and 76 with relatively high levels of nearby nature. The composite participant profile is that of a 34-year-old African American single woman with a high school or high school equivalency diploma raising three children on an annual household income of less than \$10,000.

Individual interviews were conducted during summer and fall months in participants' apartments. Residents' attentional capacity, aggression, and a number of control variables likely to be associated with aggression were assessed as part of a 45-minute structured interview.

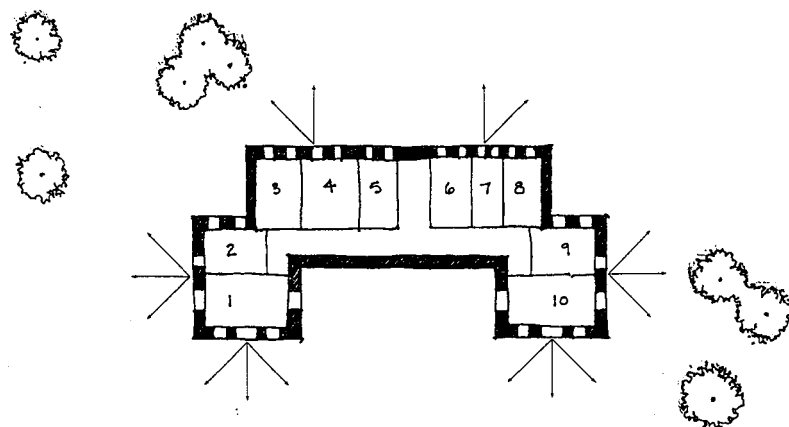


Figure 2: Plan View of an Apartment Building at Robert Taylor Homes With Nearby Trees

NOTE: The numbers within the building indicate apartments. The arrows indicate the position from which photographs were taken (for each building) that were then rated by 22 independent raters. Note that despite the presence of trees outside a building, residents in particular apartments may have little or no visual access to trees.

MEASURES

Nearby nature. Levels of nearby nature were assessed using standardized sets of photographs and multiple independent raters. For each of the 18 buildings to be sampled, a standardized set of photographs was taken from eye level of the area immediately surrounding the building. As Figure 2 shows, each standardized set comprises 16 photographs taken from specified vantage points; most showed views looking out from the building, and the remaining showed views looking across the building.

To obtain ratings of the nearby nature for each building, the photographs were arranged at 18 stations (drawing tables in a design studio), with each station showing all 16 photographs for a given building. Undergraduate and graduate students in horticulture then independently rated levels of nearby nature for each of the 18 buildings. First, raters visited each of the stations to familiarize themselves with the range of vegetation in the 18 buildings. Second, they visited each station again in turn and provided a single greenness rating for each building based on the 16 photographs. Raters were encouraged to use the entire response scale from 0 to 4 (0 = *not at all green*, 1 = *a*

little green, 2 = *somewhat green*, 3 = *quite green*, and 4 = *very green*). For each building, greenness ratings from the 22 raters were averaged to produce a summary greenness rating. These averaged greenness ratings ranged from 0.8 for the building with the least nearby nature to 3.6 for the greenest building.

With these data, agreement between raters is analogous to the reliability of items in a scale; the hope is that different raters will respond to a particular building in a similar fashion. Thus, to assess interrater agreement, a Cronbach's alpha was calculated, with individual raters treated as individual items in a scale and individual buildings treated as individual respondents. This procedure yielded an alpha of .97, indicating a high level of agreement between raters with regard to building greenness.

Greenness ratings were used as the basis for assignment to conditions. Buildings whose ratings fell below the midpoint of the range were designated *barren*; buildings whose ratings were at or above the midpoint were designated *green*. Greenness ratings for the 7 buildings in the barren condition ranged from 0.8 to 1.7, with a mean of 1.2. Greenness ratings for the 11 buildings in the green condition ranged from 2.0 to 3.6, with a mean of 2.6. In interpreting these ratings, it should be noted that because raters were encouraged to use the entire response scale, even a high greenness rating of 3.6, or *very green*, is relative to the range of vegetation at RTH; as Figure 1 shows, even the greenest pockets at RTH are neither especially large nor especially lush in vegetation.

There were no systematic differences between barren and green buildings in environmental factors such as pedestrian or automobile traffic, nearness to parking, or nearness to parks, schools, or other facilities. There was no systematic pattern in the sequence of green and barren buildings along the 3-mile corridor; green and barren buildings were not clustered but rather haphazardly interspersed. Some barren buildings were oriented north-south, others east-west; similarly for green buildings. For barren buildings, in the places where trees or grass might have been, there was only bare dirt or asphalt, and even the green buildings were surrounded by large areas of bare dirt or asphalt.

To check for possible condition differences in participant characteristics for barren versus green buildings, a series of *t* tests was conducted. As would be expected given random assignment of residents to nature conditions, no significant condition differences were found in demographic characteristics, household characteristics, or other variables potentially related to aggression. Specifically, green and barren participants did not differ in age, education, employment, income, size of household, marital status, number of

children, years in apartment, years in public housing, health ratings, health symptoms, alcohol use, prescription drug use, or other drug use.

Attentional functioning. The capacity for directed attention was assessed with the Digit Span Backwards (DSB) test. Digit Span Backwards is a standardized neurocognitive measure and is used in the measurement of attentional fatigue (Cimprich, 1993; Schwartz, 1994; Tennessen & Cimprich, 1995) and in the clinical measurement of attention (Lezak, 1983; Mesulam, 1985). DSB is particularly useful for field settings because it is easy to administer: The administrator reads aloud a series of digits (e.g., “2, 5, 1”), and participants are asked to repeat back the series in reverse order (e.g., “1, 5, 2”). Series are administered in increasing length; if a participant fails a series of a given length, a second series of equal length is administered. Scoring was based on the longest series performed correctly within two attempts.

Aggression. The Conflict Tactics Scale (CTS) (Straus, 1979) is a widely used self-report measure designed to assess levels of intrafamily aggression and violence. It has been used in more than 100 studies (see bibliography in Straus, 1995). The CTS has a test-retest reliability of .97 (parent-to-child aggression) (DuRant, Pendergrast, & Cadenhead, 1994), an internal consistency of .88 (wife-to-husband aggression) (Straus, Gelles, & Steinmetz, 1980), and good concurrent validity with other measures of parental psychosocial distress (Wissow, Wilson, Roter, Larson, & Hope, 1992).

To elicit reports of aggressive behavior, participants are asked to think of situations in which they had a disagreement or were angry with a specified family member and to indicate how often they used each of 18 conflict tactics, beginning with socially acceptable tactics (e.g., reasoning) and ending with violent tactics. Table 1 shows the 14 aggressive conflict tactics from the CTS. The responses to these 14 items provide an index of overall aggression. The first 6 items index psychological aggression: verbal and symbolic acts intended to cause psychological pain or fear. The remaining 8 items index violence: the use of physical force or violence. These 8 items comprise both mild violence (3 behaviors unlikely to cause injury) and severe violence (5 behaviors likely to cause injury).

For each of the specific conflict tactics, participants are asked to indicate how often they have used it in the past 12 months on a 7-point scale (0 = *never* to 6 = *more than 20 times*, with X = *don't know*). If participants reply never or don't know, they are then asked, “Did you ever . . . ?” (yes/no). These questions are asked in reference to two specified family members—first the

TABLE 1
Overall Aggression Items From the Conflict Tactics Scale

Psychological aggression
Insulted or swore at the other
Sulked or refused to talk
Stomped out of the room or house
Did or said something to spite the other
Threatened to hit or throw something
Threw or smashed or hit or kicked something
Violence
Mild violence
Pushed, grabbed, or shoved the other one
Slapped the other one
Threw something at the other one
Severe violence
Kicked, bit, or hit with a fist
Hit or tried to hit with something
Beat up the other one
Threatened with a knife or gun
Used a knife or gun

respondent's partner (or the adult with whom they are closest) and then their child (or if they have more than one, the child with whom they have the most conflicts).

This procedure yields estimates of both the frequency of specific aggressive behaviors used in the past year and the range of aggressive behaviors employed over the respondent's lifetime. In general, more aggressive persons employ a wider range of aggressive behaviors; for instance, Person A might only use verbally aggressive tactics, whereas Person B might use not only verbally aggressive tactics but also physically aggressive tactics. For each of the different categories of aggression (overall aggression, psychological aggression, and so forth), the range of tactics a respondent has used in that category is calculated by taking the proportion of the number of different tactics employed out of the total number of different tactics. For instance, an individual who has employed each of the 14 different overall aggression tactics would have an overall aggression range of 1.0; an individual who has employed only 7 of those tactics (typically, the less serious ones) would have an overall aggression range of 0.5. Similarly, the range of violent tactics would refer to the proportion of the 8 violent tactics that a respondent had employed. It should be noted that the term *range* is not used in the statistical sense here; the different conflict tactics are not assumed to be on an interval scale.

Other factors likely to affect aggression. Three additional variables that seemed likely to be related to nearby nature, attention, or aggression were assessed through self-report using a 5-point scale (0 = *not at all*, 1 = *a little*, 2 = *a medium amount*, 3 = *quite a lot*, and 4 = *very much*). Positive mood was assessed with the Positive Mood subscale of the Profile of Mood States (POMS). Participants rated themselves on six adjectives (lively, active, energetic, cheerful, full of pep, and vigorous). The POMS has been shown to be a valid and reliable instrument for the measurement of mood (McNair, Lorr, & Droppleman, 1981). Stress was assessed with the question "How stressful is this period in your life?" And social integration was assessed with an 8-item scale, $\alpha = .80$, that included items such as "How well do you know the people next door?"; "Are people here concerned with helping and supporting one another?"; and "Is there a strong feeling of belonging here?" (see Kuo et al., 1998, for details).

RESULTS

Results are presented in three subsections. First, descriptive statistics on intrafamily aggression and participants' attentional resources are presented. Second, the central hypothesis is tested. And third, potential mechanisms underlying the relationship between nearby nature and aggression are explored.

AGGRESSION AND MENTAL FATIGUE AT ROBERT TAYLOR HOMES

Consistent with previous research, levels of aggression in this population were much higher than in national samples. A majority of participants in this sample (61%) reported having engaged in a violent act against their partner at least once in their lives, a rate approximately 4 times that reported in two national probability samples of couples in the United States (Straus, 1979; Straus & Gelles, 1988) but consistent with rates from a sample of formerly married African American women (57%) (Neff, Holamon, & Schluter, 1995). Aggression against children showed much the same pattern. A majority of the participants in this sample reported hitting their child with something at least once in their lives (56%), approximately 4 times the rate reported in a national sample of two-caretaker households with at least one child (Straus & Gelles, 1986).

Participants' DSB scores provide an index of attentional resources in this inner-city population. According to Lezak (1983), scores of 4 or 5 on this version of the DSB test are within normal limits, depending on the individual's educational level. In this sample, the mean DSB score was 4.8, with a standard deviation of 1.1, indicating substantial variation in attentional functioning.

TESTING THE CENTRAL HYPOTHESES

If the availability of nearby nature reduces the propensity for aggression, then residents living in green conditions should report less aggression than their counterparts living in barren conditions: less frequent aggression in the past year and a narrower range of aggressive tactics used over the course of their lifetime. A series of planned, one-tailed *t* tests were conducted to examine condition differences in frequency and range of aggression, first against the respondent's partner and then against their child.

Aggression against partner. Tables 2 and 3 show the findings with respect to the frequency of aggression against partner in the past year and the range of aggressive tactics used against partner over the lifetime.

As the first row of Table 2 shows, there was a significant condition difference in the frequency of overall aggression against partner during the past year. That is, residents living in green conditions reported significantly less overall aggression against their partners than did their counterparts living in barren conditions. The following rows in Table 2 show the findings for specific forms of aggression. The second row indicates that there was a significant condition difference in psychological aggression against partner; residents living in green conditions were significantly less likely to have engaged in psychological aggression against their partners than were residents living in barren conditions. Does this effect extend to more violent forms of aggression? Because the violence indices produce extremely skewed distributions, Straus (1979) recommended dichotomizing these indices into violent and nonviolent categories. If a participant had engaged in at least one of the eight violent conflict tactics during the past year, they were designated violent; otherwise, they were designated nonviolent. As rows 3 through 5 of Table 2 show, nearby nature is related to the use of violence against partner during the past year. Violence scores were significantly lower for residents living in green conditions than those living in barren conditions. Furthermore, this pattern held for both the more mild forms of violence and the more severe forms of violence. Both mild violence rates and severe

TABLE 2
Mean Rates of Aggression Against Partner
During Past Year in Green Versus Barren Condition

	<i>Barren</i>		<i>Green</i>		t	p
	M	SD	M	SD		
Overall aggression	1.04	0.88	0.76	1.07	1.68	< .05
Psychological aggression	1.47	1.20	1.00	1.26	2.24	.01
Violence	0.73	0.45	0.49	0.50	2.99	< .01
Mild violence	0.73	0.45	0.49	0.50	3.06	.001
Severe violence	0.48	0.50	0.31	0.47	2.10	< .05

NOTE: The response scale for the original items in this table was from 0 (*never*) to 6 (*more than 20 times*). Because the violence, mild violence, and severe violence indices were skewed, we followed Straus's (1979, p. 80) recommendation that these scales be dichotomized into violent and nonviolent categories. Thus, for these three indices, 0 indicates having engaged in none of the specific tactics during the past year, and 1 indicates having engaged in at least one of the tactics during the past year. Degrees of freedom ranged from 136 to 140.

TABLE 3
Range of Aggression Tactics Used Against Partner
in Lifetime in Green Versus Barren Conditions

	<i>Barren</i>		<i>Green</i>		t	p
	M	SD	M	SD		
Overall aggression	.44	.28	.32	.30	2.39	< .01
Psychological aggression	.58	.36	.44	.35	2.46	< .01
Violence	.32	.27	.24	.32	1.54	.06
Mild violence	.52	.39	.35	.40	2.50	< .01
Severe violence	.19	.24	.16	.29	0.80	.22

NOTE: In response to questions about having ever used specific aggressive conflict tactics, participants responded never (0) or yes (1). Standard deviations are in parentheses; degrees of freedom ranged from 136 to 140.

violence rates were significantly lower in the green condition than in the barren condition. Mean differences between the green and barren conditions for the various aggression subscales ranged from one third to one half of a standard deviation.

Table 3 shows the findings with respect to the range of aggressive conflict tactics used against partner over the participant's lifetime. As the first row shows, there was a significant condition difference in the range of overall aggression tactics used. That is, residents living in green conditions report

using a narrower set of aggressive conflict tactics against their partners over their lifetime than did their counterparts living in barren conditions. The following rows in Table 3 show the findings for specific forms of aggression. The second row indicates that there was a significant condition difference in psychological aggression against partner; residents living in green conditions used a significantly narrower set of psychologically aggressive conflict tactics than did residents living in barren conditions. The third row of the table suggests that nearby nature may be related to the range of violent conflict tactics used against partners. For residents living in green conditions, the set of violent tactics used was 25% smaller than for those living in barren conditions, a marginally significant difference ($p = .06$). Although there was no difference in the range of severe forms of violence used against partners, there was a significant condition difference in more mild forms: Residents living in green conditions report using a smaller set of mildly violent conflict tactics against their partners over their lifetime than did their counterparts living in barren conditions. Mean differences between the green and barren conditions ranged from more than one quarter to one half of a standard deviation.

Aggression against a child. The conditions leading to aggression against an adult family member may be quite different from those leading to aggression against one's child. Conflicts with children are likely to be more frequent than those with adult family members and often center around disciplinary issues. At the same time, some forms of aggression may be less socially acceptable against children than against adults. Does the relationship between nearby nature and aggression found for women and their partners exist for women and their children? Condition differences were examined for aggressive conflict tactics used with children, specifically, the child with whom the participant had the most conflicts. A t test showed that greenness was related to the range of psychologically aggressive tactics used against children: Lifetime scores for proportion of psychologically aggressive tactics used were significantly lower for participants living in the green condition than for their counterparts living in the barren condition (.54 vs. .62), $t(140) = 1.83$, $p < .05$. But the effect did not hold for the frequency of psychological aggression during the past year or for the frequency or range of more violent forms of aggression against children.

In sum, there were a number of indications that nearby nature has a mitigating effect on aggression and violence: Nearby nature was systematically related to lower scores on multiple indices of aggression against partners and one index of aggression against children.

TESTING FOR UNDERLYING MECHANISMS

What mechanism or mechanisms might underlie the association between nearby nature and aggression? The following analyses tested for each of the following: the proposed mechanism, the possibility that some unspecified mechanism might be at work, and three specific alternative mechanisms.

If effects of nearby nature on aggression operate through attentional restoration, a number of predictions follow. First, residents living in green conditions should show higher levels of attentional functioning than their counterparts living in barren conditions. A planned student *t* test showed that indeed, mean DSB scores were significantly higher in the green condition ($M = 5.0, SD = 1.0$) than in the barren condition ($M = 4.6, SD = 1.2$), $t(138) = 1.74, p < .05$, differing by more than one third of a standard deviation.

Second, if effects of nearby nature on aggression operate through attentional restoration, then attentional functioning should be systematically related to aggression. Using the lifetime measure of overall aggression against partner as a summary index of aggression, an ordinary least squares regression was conducted using DSB scores to predict levels of aggression. As predicted, there was a significant negative relationship between DSB performance and overall aggression ($\beta = -.26, R^2 = .07, F = 9.9, p < .0025$). By this summary measure of aggression, the better a participant's attentional functioning, the less aggression she had engaged in.

And finally, if effects of nearby nature on aggression operate through attentional restoration, the relationship between nature and aggression should statistically depend on the relationship between attention and aggression. These interdependencies are important to examine when hypothesizing mediation because significant associations among three variables are possible without there being a mediation relationship between them. For example, in this case, nearby nature might enhance attention and reduce aggression but influence aggression through some other mechanism than attention. In that case, the nature-aggression relationship would most likely be statistically independent of the nature-attention relationship. If, on the other hand, contact with nearby nature reduces aggression via the restoration of attentional resources, we would expect the nature-aggression relationship to diminish or disappear when attention is statistically controlled.

Accordingly, a multiple regression was used to test for the joint relationships among nearby nature, attentional performance, and levels of aggression. When DSB (the proposed mediator) was controlled in a regression between greenness and overall aggression, greenness was no longer a significant predictor ($\beta = -.13, p = .11, R^2 = .09, F = 6.5, p < .0025$). Complete, or

“perfect,” mediation requires that the independent variable has no additional predictive power when the mediator is controlled (Baron & Kenny, 1986); thus, these findings indicate that attentional restoration could be the sole mechanism underlying the nature-aggression relationship found here.

Could the links among nature, attention, and aggression be explained by some unspecified confounding variable or some alternative mechanism? Evans and Lepore (1997) suggested addressing what they referred to as “the spuriousness problem” by conducting an analysis in which the relationship between the hypothesized mediator and the outcome variable is examined while the independent variable is controlled. By their reasoning, if there is some unspecified confounding variable responsible for the relationships among nature, attention, and aggression, then attention will not be significantly related to aggression when nature is controlled. In fact, the multiple regression described earlier addresses this possibility: DSB was a significant predictor of overall aggression ($\beta = -.24, p < .01$) when greenness was controlled. This finding indicates that some unspecified mechanism cannot account for the relationships among DSB, greenness, and overall aggression.

These findings were echoed in follow-up analyses examining the following three specific, theoretically plausible, alternative mechanisms: positive mood, stress, and social integration. Planned student *t* tests showed that greenness was unrelated to positive mood, $t(142) = -.04, p = .48$, and stress, $t(140) = .17, p = .43$, but was related to social integration, $t(140) = 2.7, p < .01$. Correlational analyses showed that overall aggression was related to neither mood, $r(141) = -.07, p = .48$, nor stress, $r(139) = .135, p = .11$, nor social integration, $r(142) = -.06, p = .48$. Together, these results indicate that neither positive mood, nor stress, nor social integration mediate the nature-aggression relationship found here. Moreover, these analyses reinforce the aforementioned mediation and spuriousness findings, indicating that the effect of nature on aggression found here may be wholly mediated through attentional restoration.

DISCUSSION

In 145 adult women randomly assigned to a series of architecturally identical apartment buildings, levels of aggression and violence were significantly lower among individuals who had some nearby nature outside their apartments than among their counterparts who lived in barren conditions. Furthermore, as would be predicted if this relationship were mediated by mental (attentional) fatigue, (a) residents living in greener settings

demonstrated reliably better performance on measures of attentional functioning, (b) attentional performance predicted scores on a summary index of aggression, and (c) the relationship between nearby nature and aggression scores became nonsignificant when attention was controlled. Finally, follow-up analyses examining potential alternative mediators revealed no significant relationships between aggression and mood, stress, or social integration, and a test for unspecified mediators similarly ruled out alternative mechanisms.

It should be noted that the predicted relationship between nearby nature and aggression was not consistently found for more violent forms of aggression or for aggression against children. Of the various forms of aggression examined in this study, these may be the most susceptible to social desirability effects. Future research might use other strategies to examine the nature-aggression relationship for forms of aggression that are most difficult to assess through self-report.

To what extent can the nature-aggression relationship found here be interpreted as an effect of nearby nature on aggression? The following considerations lend confidence in a causal interpretation of these data: the random assignment of residents to nature condition; the consistently negative findings across numerous checks for condition differences in participant, household, and interviewer characteristics; the consistency of architectural and other environmental features over the two conditions; the use of multiple buildings per condition; and the use of double-blind measures for both nearby nature and aggression. Numerous tests were conducted to identify the particular causal pathway between nature and aggression. Results from all of these tests were of one accord: The mediation tests indicated a pathway through attention, and the spuriousness test and direct tests of alternative mediators all worked to rule out other possible pathways. Although other possibilities cannot be ruled out entirely, the only interpretation consistent with the complete set of findings here is that nearby nature reduces aggression by supporting attentional functioning. At this juncture, attention restoration theory (S. Kaplan, 1995) provides the best explanation for the link between nature and aggression.

Having addressed the question of internal validity, we turn now to external validity. To what extent do the relationships found in this study generalize to the real world? External validity depends in large part on how the constructs in a study are operationalized. In this study, the constructs were operationalized as directly as possible; to the extent we could, we avoided using surrogates or proxies. For example, measuring the vegetation around participants' homes was a more direct way to assess the effects of residential

nature than, say, showing slides of nature in a classroom. Similarly, using a performance measure of attention provided a more direct measure of attentional functioning than asking participants to rate how attentive they feel. And, asking participants to estimate the actual frequency of specific aggressive behaviors in the past year provided a more direct measure of in situ aggression than obtaining ratings of feelings of aggression in a laboratory setting or eliciting hostile attributions in hypothetical contexts. Relying on relatively direct measures of nature, attention, and aggression lends greater confidence that the relationships found here are true outside of this study. The large sample size employed (145 participants) further strengthens the case for external validity.

At the same time, there is reason for caution in assuming that these effects generalize to forms of aggression not studied here or to aggression in other populations and settings. Although the mental fatigue hypothesis should apply to many forms of aggression and it is quite clear that both men and women are subject to mental fatigue, this work examined only intrafamily aggression by women. Future research should examine effects of nature on aggression by men and other forms of aggression (e.g., road rage and gang violence).

These qualifications notwithstanding, domestic violence is an important topic in and of itself, and findings with regard to domestic violence have far-reaching implications. A substantial literature has established that compared with children from nonviolent families, children of violent families are more likely to grow up to be violent. This increased risk for violent behavior includes not only children who were victims of abuse but also those who witnessed abuse (Bandura, 1973, 1978; DuRant et al., 1994; Rice & Remy, 1998; Wissow et al., 1992; Wolfe, Jaffe, Wilson, & Zak, 1985). Thus, identifying possible avenues to reducing domestic violence may pay benefits for generations to come. By reducing intrafamily aggression and thus children's socialization into aggressive and violent behaviors, green neighborhood spaces may indirectly reduce aggression in future generations.

This work has implications for understanding and preventing aggression and for our understanding of the psychological effects of natural environments.

UNDERSTANDING AND PREVENTING AGGRESSION

One contribution of this work is to suggest a potential explanation for a number of poorly understood phenomena in the environment-behavior literature on human aggression. Mental fatigue might help account for the relationships found between crowding and aggression (Ani & Grantham-McGregor,

1998; Nijman & Rector, 1999; Palmstierna, Huitfeldt, & Wistedt, 1991) and noise and aggression (Donnerstein & Wilson, 1976; Gaur, 1988; Geen & McCown, 1984; Sherrod, Moore, & Underwood, 1979), and for urban-rural differences in aggression (Fingerhut, Ingram, & Feldman, 1998). Noise and crowding both seem likely to place demands on attention (Cohen & Spacapan, 1978), and urban environments tend not only to be noisier and more crowded than rural environments but also less green than rural environments. Thus, urban environments seem likely to be more attentionally fatiguing and less attentionally restorative in general than rural environments. Future research might examine whether these phenomena are indeed fatigue related.

This work may also offer insight into some phenomena in human aggression that do not necessarily involve the physical environment. For example, both the extremely high rates of aggression and violence in poor families and the link between stressful life events and aggression (Guerra, Huesmann, Tolan, Van Acker, & Eron, 1995; Hammond & Yung, 1991; Patterson, Kupersmidt, & Vaden, 1990; Spencer, Dobbs, & Phillips, 1988; Straus et al., 1980) might be explained at least in part by mental fatigue. As described in the introduction, poverty is likely to place relatively high, unremitting demands on attention. And stressful life events such as moving to a new home or having a family member become seriously ill can involve substantial amounts of problem solving, contingency planning, and other attentionally demanding, mentally fatiguing forms of cognition. If the relatively high rates of aggression associated with poverty and stressful life events are indeed partially attributable to mental fatigue, future research should find links between poverty and mental fatigue as well as links between stressful life events and mental fatigue.

This work also suggests a number of possible interventions for addressing aggression and violence in the inner city. Specifically, efforts to improve conflict behavior might involve preventing, detecting, and treating attentional fatigue. For example, conflict behavior might be improved by preventing attentional fatigue through reducing the attentional demands of the environment by means of soundproofing, reducing crowding, and increasing safety. Similarly, providing insurance against the drastic life changes to which the poor are most susceptible might also help prevent fatigue and fatigue-related aggression. DSB and other tests of attentional functioning might help detect fatigue and let individuals know when they are most at risk for aggressive or violent behavior. Finally, strategies for treating attentional fatigue, including taking green breaks and getting more sleep, might help prevent fatigue-related aggression.

UNDERSTANDING THE EFFECTS OF NATURAL ENVIRONMENTS ON HUMAN BEHAVIOR

This work contributes to our understanding of the psychological effects of natural environments in a number of ways. First, the findings provide strong evidence for a potential effect of nature that has been largely unexplored—reducing aggression and violence. Previous research on the effects of nature has focused on its effects on mood, recovery from stress, everyday functioning, and attention (e.g., Cimprich, 1993; Hartig et al., 1991; Hull & Michael, 1995; Ulrich et al., 1991), and only two previous studies have hinted at a potential effect of nature on aggression (Mooney & Nicell, 1992; Rice & Remy, 1998). This study demonstrates a link between nature and reduced aggression in an experimental design and provides clear support for the proposed mechanism of attentional restoration. In doing so, it extends attention restoration theory and shows that the theory has implications for a concern as important and socially relevant as levels of aggression and violence in inner-city neighborhoods.

A second contribution is to raise an interesting question with regard to the benefits of residential nature. In these data, the vegetation around apartment buildings was significantly related to measures of attentional functioning but not to measures of stress or positive mood. This is consistent with the previous literature: Other studies have found significant relationships between residential vegetation and measures of attention (R. Kaplan, 2001 [this issue]; Tennessen & Cimprich, 1995), and to date we are unaware of any studies demonstrating links between residential nature and either stress or positive mood. Are there in fact no relationships between residential nature and stress or residential nature and mood? Perhaps these relationships exist and the procedures in this study simply failed to uncover them. It also seems possible that mood and stress are simply not affected by highly habituated forms of nature. This seems a fascinating question for future research.

A third contribution of this work concerns the density and extent of nature necessary to convey benefits. It might seem implausible that a few trees and grass in relatively small areas outside public housing apartment buildings could have any clear effects on residents' levels of aggression. Yet this low dose of vegetation has been shown to have far-reaching and positive effects on a number of other important outcomes, including residents' management of major life issues (Kuo, 2001) and neighborhood social ties (Kuo et al., 1998; Kweon et al., 1998). Future research might explore how the benefits of contact with nature vary as a function of the density of vegetation.

A final contribution of this work is to suggest that the geographic distribution of natural areas matters. Although large central or regional parks are

clearly important components of urban design, the results of this study suggest that a few major parks are not enough. All residents of RTH live within 2 miles of one of the most extensive examples of urban nature in North America—Lake Michigan and the parks along Lake Shore Drive in Chicago. Yet the proximity to these tremendous natural resources is apparently insufficient to keep all residents of RTH at similar levels of attentional functioning. Perhaps, as Rachel Kaplan (1985) suggested, cities should be designed with nature at every doorstep.

NOTES

1. Given that residents do have some choice of apartment within Robert Taylor Homes (RTH), it seemed possible (although not likely) that better functioning and therefore potentially less aggressive residents might self-select into greener buildings. As a check on that possibility, participants were asked what criteria were important to them in choosing a place to live: Of 118 responses, 93% were clearly unrelated to levels of vegetation (47% of respondents “just needed a place;” 12% desired safety or cleanliness; 10% were concerned about access to work, school, or family; 9% were concerned about cost; 8% were concerned about space or number of bedrooms; 6% wanted an apartment on a “low floor,” perhaps because of the frequency of elevator malfunctions; and 1 participant mentioned sense of community). Seven percent of respondents expressed concerns that might be interpreted as related to levels of vegetation (e.g., location, neighborhood, area, and environment), and 1 participant of the 145 specifically reported that a “natural setting” was important to her. However, analyses indicated that these participants lived in no greener areas on average than the remainder of the participants in this study. Thus, the level of nearby nature does not seem to be an important criterion in residents’ selection of apartments within RTH; moreover, it appears that the level of choice residents have in selecting an apartment is sufficiently low that even residents who might strongly value access to nature are no more likely to be assigned to a green area.

2. Eligibility requirements for public housing and some other forms of public aid favor single mothers. This creates a pressure for families not to list adult males as official residents (and for these unofficial residents not to participate in studies about life at RTH).

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