AT HOME WITH NATURE
Effects of "Greenness" on Children's Cognitive Functioning

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ABSTRACT: The nearby natural environment plays a far more significant role in the well-being of children residing in poor urban environments than has previously been recognized. Using a premove/postmove longitudinal design, this research rules out the effects of various extraneous variables that have plagued previous studies and explores the linkage between the naturalness or restorativeness of the home environment and the cognitive functioning of low-income urban children. Both before and after relocation, objective measures of naturalness are employed along with a standardized instrument measuring the children's cognitive functioning. Results indicate that children whose homes improved the most in terms of greenness following relocation also tended to have the highest levels of cognitive functioning following the move. The implications with respect to policy and design are also discussed.

> By the time my children are ready to begin school, never mind graduate, they're tired. They've been fighting the rats, and have to shiver on account of

AUTHOR'S NOTE: *Preparation of this article was partially supported by the University of Michigan Rackham Graduate School; the USDA Forest Service, North Central Forest Experiment Station; the USDA New York State, Hatch Grant 327407; the Environmental Design Research Association; and the Doctoral Program in Architecture and the Department of Psychology at the University of Michigan. I am very grateful to Habitat for Humanity and to the families who participated in this study. Thanks to Steve Kaplan, Rachel Kaplan, and Leon Pastalan for their input on early drafts of this article. Special thanks to Savitha Shastry for her many hours of assistance with data collection and data entry. Thanks also to Terry Chang for data entry assistance.*

ENVIRONMENT AND BEHAVIOR, Vol. 32 No. 6, November 2000 775-795

> the cold inside the building, and they fall and stumble on those broken-down stairs . . . the electricity, it doesn't work half the time, and what can you see out of here, but the garbage that the city doesn't care to pick up? No one says that when kids have to live in houses like this, and they have to live in neighborhoods like this, that it's not the end for them before they can even start. (Anonymous mother in Coles, 1966, p. 48).
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> Pharaoh . . . crouched in the weeds nearby, his legs tucked underneath him, and picked at the vegetation, which now reached his neck. He was lost in his thoughts, thoughts so private and fanciful that he would have trouble articulating them to others. He didn't want to leave this place, the sweet smell of wildflowers and the diving sparrow. There was a certain tranquillity here, a peacefulness that extended into the horizon like the straight, silvery rails. (Kotlowitz, 1992, p.7).

CHILDREN AND POVERTY

In 1996, more than 13 million children in the United States were living below the poverty line. Among White children, 16% live in poverty, whereas nearly 40% of African American children live in poverty (U.S. Bureau of the Census, 1998). Along with poverty often come substandard housing conditions—commonly characterized by overcrowding, infestation by rodents or insects, and lack of adequate heat or plumbing. According to a recent study by the U.S. Department of Housing and Urban Development, a record 5.3 million low-income households are paying more than 50% of their income for rent or are living in severely substandard housing ("In Our Opinion," 1998).

Children living in poverty commonly face a host of environmental challenges such as poor housing, deteriorated neighborhoods, and overcrowded schools, not to mention the prevalence of social ills such as crime, violence, and racism. Within this context, it is likely that housing conditions can have a strong effect on young occupants. Yet the nature of this effect is unclear. The extant empirical literature provides little evidence regarding the housing characteristics that matter. Of particular interest in this article, the extent of the naturalness of children's home environment has received virtually no research attention. Does the view from a child's home affect his or her well-being? Do nearby trees make a difference in cognitive functioning? There is a growing body of evidence suggesting that these factors are generally important to human well-being, but there is little clarity regarding their significance to children within the home environment. Before considering the question of nature in the home, I will first review the literature regarding the effects of housing on children.

HOUSING AND CHILDREN'S WELL-BEING

Research tells of a variety of ways that the environment affects children. Highway noise near one's apartment building slows the development of children's reading skills (Cohen, Glass, & Singer, 1973). Residential crowding increases tension between parents and children and may also lead to a greater sense of helplessness (Evans, Lepore, Shejwal, & Palsane, 1998). Exposure to lead can result in mental retardation, hyperactivity, or illness (Needleman 1994; Spreen, Tupper, Risser, Tuoko, & Edgell, 1984). Severe lack of stimulation, as experienced by children in orphanages, was shown to lead to lower IQ scores, social withdrawal, and greater frequency of physical illnesses (Spitz, 1945). On the more positive side, settings that are responsive and more readily manipulatable support cognitive development in infants (Wachs & Gruen, 1982). However, there is still a substantial gap in our knowledge of how physical aspects of the home environment affect children.

Housing Quality

Although many studies have addressed the effects of housing quality on adults, few have examined the effects of housing quality on children. Studies conducted by Obasanjo (1998) deal with adolescents but may provide some insight with respect to younger children. Obasanjo found that poor housing quality (measured by 17 self-report items) was highly predictive of high rates of psychosomatic illness (e.g., headaches, dizziness, shortness of breath), poor cognitive control, and high levels of directed attention fatigue among inner city adolescents age 15 to 19. Although he did not find natural or restorative resources to be predictive of these dependent variables, the author suggests that this may be due to the fleetingness of the urban youths' experiences with nature or due to an association of urban parks and natural areas with crime, violence, and gang activity. In a subsequent study, Obasanjo found housing quality to be predictive of perceived social support, psychosomatic illnesses, and directed attention fatigue among 680 inner-city Chicago adolescents. It is interesting that the effects of housing quality on the latter two dependent variables (psychosomatic illnesses and directed attention fatigue) were moderated by age, such that younger adolescents were more profoundly affected. This suggests that housing quality may have particularly critical effects on younger adolescents or children, perhaps because they are more vulnerable or because they spend more time in the home.

A study in Northern Ireland examined a historically problematic area of inner-city, high-density public sector housing where residents complained of

leaking sewage, rat infestation, fire hazards, and lead pollution. Blackman, Evason, Melaugh, and Woods (1989) used, as a rather crude control, another area of public sector housing with similar levels of deprivation but with markedly superior housing. In the poorer housing area, they found greater incidence of psychological distress among children (i.e., bed wetting, depression/weeping, inability to concentrate, feelings of hopelessness, and loss of appetite). It is interesting that the two groups differed not only with respect to housing quality, but also in housing type: inner-city flats versus houses with gardens. Is it possible that the view of a yard or garden space could, at least in part, account for the between-groups differences in psychological well-being and ability to concentrate?

The two Obasanjo studies (1998) and the Blackman et al. (1989) study all provide support for the notion that housing quality makes a difference in psychological and cognitive well-being. However, they present an ambiguous picture with respect to the potential impact of the natural environment. Studies regarding housing types may provide more insight.

Housing Type

The bulk of research on housing type and children's well-being focuses on the effects of high-rise living, with an emphasis on children's behavioral problems, physical health, and play behavior.

First, I will consider the evidence regarding high-rise living and behavioral problems among children. Ineichen and Hooper (1974) found twice as many children residing in high-rise apartments exhibited behavioral problems (e.g., temper tantrums, destroying things, wetting the bed, or refusing to go to school) than did children in contrasting (not high-rise) residential areas. Consistent with the Ineichen and Hooper finding, Richman (1977) found significantly greater severe behavioral problems among preschool children living in high-rise buildings than among those living in other types of housing. Children in this study were matched on socioeconomic status and gender. Saegert (1982) studied 312 elementary school children whose families were randomly assigned to apartments in 3-story or 14-story public housing buildings. She found that among boys, teachers' ratings of behavioral disturbance were higher for 14-story building residents than for 3-story residents. Among girls, however, there were no differences. In an ecological study using census tracts as the unit of analysis, Gillis (1974) found housing type to be a significant predictor of juvenile delinquency. Areas with multiple unit

dwellings were more associated with juvenile delinquency than those areas with predominantly single detached housing.

Other studies have focused on differences in physical illness between children residing in different types of housing. Fanning (1967) studied differences between families residing in 3- and 4-story apartments surrounded by an open space with grass and those living in houses with individual gardens. He found that respiratory illnesses were more common among children younger than 10 living in flats than among their nearby counterparts living in houses. Goodman (1974), using only descriptive statistics, provided similar evidence that total illness rates were higher among residents of flat and maisonettes (within an 8-story mid-rise) than among those living in houses. Goodman does not provide any description of the outdoor environment.

Some researchers have focused on the effects of high-rise living on play behavior. Churchman and Ginsburg (1984) found that among children age 4 and 5 (but not among children age 2 to 3 or 6 and older), a larger percentage of those residing in high-rises could not play outside than those living in low-rise apartments. This finding is consistent with that of a British Department of the Environment (BDOE; 1973) study that showed, based on behavioral mapping, that children living at or close to ground level were more often seen playing outside. Furthermore, Gittus (1976) studied 346 working-class families with children younger than 5 and found that children in high-rises had more restricted play and were more likely to play alone, and their mothers were less satisfied with play facilities than those living in low-rises or in single dwellings.

In general, studies of high-rise living have found that children who live in high-rise housing tend to exhibit more behavioral problems, have more restricted play, and have poorer physical health than do those who reside in low-rises or single-family dwellings. These findings have generally been interpreted as evidence that living on higher floors leads to social isolation and restriction of play activities, which in turn results in poor behavior and well-being. An alternative (or complementary) explanation would be to consider the connection to the natural environment as a mediating variable. Perhaps high-rise residents' distance from a green view is a more relevant factor than has typically been considered. One study suggests this may be the case. In a study of elderly people living in either high-rise or garden apartments, Devlin (1980) found that those in garden apartments were significantly more satisfied with their housing than were high-rise residents, and they cited proximity to nature as a primary source of their satisfaction.

THE RESTORATIVE EFFECTS OF THE NATURAL ENVIRONMENT

The Literature

There is a substantial body of literature demonstrating the cognitive and psychological benefits of natural environment experiences (see R. Kaplan & S. Kaplan, 1989). R. Kaplan (1973) describes the psychological benefits of gardening for adults. R. Kaplan and S. Kaplan (1989) and R. Kaplan and Talbot (1988) found that wilderness challenge experiences are beneficial to adolescents. More recently, research has focused on the cognitive or attentional benefits of nature experiences. In a comparison of three groups of backpacking enthusiasts, Hartig, Mang, and Evans (1991) found that those who went on a wilderness backpacking trip showed improved proofreading performance, whereas those who went on an urban vacation or no vacation showed no such improvement. In a second study, the same authors compared the proofreading performance of participants who took a walk in a natural setting, others who took an urban walk, and a third group who engaged in passive relaxation following 40 minutes of attentionally fatiguing tasks. They found that the group engaged in the natural experience performed highest on the proofreading task (Hartig, Mang, & Evans, 1991). In a study of postsurgery breast cancer patients, Cimprich (1990) found that those who participated in a nature-oriented intervention activity showed a consistent gain of attentional capacity, whereas the nonintervention control group did not.

Various studies have shown that the view from a window can constitute an experience with nature and can make a difference. A few studies have shown the positive effects of natural views on physical health. Moore (1981) found that prisoners with natural views from their windows made fewer visits to the infirmary. West's (1986) study supported these findings in another prison environment. Ulrich (1984) and Verderber and Reuman (1987) have shown that patients in hospital rooms with natural views made fewer requests for pain medication and experienced a speedier recovery following surgery than did patients with a built view (streets and buildings) from their windows. Tennessen and Cimprich (1995) focused on the cognitive benefits of natural views. These authors found that college students with natural views had better attentional capacities than those with built views from their dormitory rooms.

Despite the plethora of research evidence suggesting that the natural environment makes a difference in the functioning of humans, little research has focused on the experiences of children, and, furthermore, little work has

focused on exposure to nature within the housing environment. A series of recent studies conducted by Kuo and Sullivan and their colleagues has begun to demonstrate the value of trees and vegetation within inner-city housing projects in Chicago (Kuo, Bacaicoa, & Sullivan, 1998). Sullivan and Kuo (1996) report that public housing residents who live in buildings surrounded by trees feel a greater sense of connectedness to the community and experience fewer incidents of violence than do residents living in identical buildings with very few trees. These studies have also begun to address the importance of nature to children. Coley, Kuo, and Sullivan (1997) found that the presence of trees and vegetation in outdoor public spaces was associated with greater use of these spaces by both youth and adult residents. The authors conclude that natural landscaping promotes opportunities for social interaction as well as the supervision of children in poor urban neighborhoods. In another study, Taylor, Wiley, Kuo, and Sullivan (1998) observed the behavior of public housing residents in two outdoor spaces: one with many trees and the other relatively barren with few trees. They found that treed spaces were more supportive of children's play and that children had more access to adults in greener outdoor spaces than in the relatively barren spaces. They point out that both of these factors, play and access to adults, are critical in children's social and cognitive development.

A study conducted in Sweden compared the effects of the natural environment on children within two different day care settings (Grahn, Mårtensson, Lindblad, Nilsson, & Ekman, 1997). The first setting, a typical urban day care with a playground area surrounded by tall buildings (and therefore protected from vehicular traffic and noise), had low plants and a brick cycling path. The second setting, based on the "outdoors in all weather" theme, had an old mature orchard surrounded by pasture on two sides, woodland on the third, and a wild, overgrown garden with tall trees and large rocks next to the building. As the term "outdoors in all weather" suggests, the children attending the second day care played outside every day for substantial periods of time. Results showed that children in the more natural day care had better motor coordination and better attentional concentration abilities (as measured by the Attention Deficit Disorders Evaluation Scale [ADDES], McCarney, 1995).

Theoretical Foundation

Much of the effects-of-nature research is based on the proposal that exposure to the natural environment helps to maintain or restore the capacity to direct one's attention, in other words, to focus or concentrate (R. Kaplan &

S. Kaplan, 1989; S. Kaplan, 1995, S. Kaplan & R. Kaplan, 1983). This theoretical perspective is rooted in the work of William James (1890) who proposed that there are two types of attention, directed or voluntary attention and involuntary attention. Directed or voluntary attention requires effort to inhibit the urge to respond to distractions around us and to focus on the task at hand. Prolonged periods requiring the use of directed attention result in mental fatigue or *directed attention fatigue*, which is characterized by having difficulty focusing on tasks, feeling irritable, and being easily distractible. According to theory, this occurs because neural inhibitory mechanisms become fatigued from blocking out competing stimuli (S. Kaplan & R. Kaplan, 1983).

S. Kaplan and R. Kaplan (1983) have suggested that four characteristics are necessary for an environment to facilitate recovery from directed attention fatigue and the restoration of attentional capacity. The first characteristic, *fascination*, is found in environments that draw one's attention effortlessly, thereby involving involuntary attention and allowing the neural inhibitory mechanism underlying directed attention to rest. Natural phenomena such as a babbling brook, the stir of leaves, or the chirps of baby birds illustrate this characteristic. *Being away* is the experience of taking a minivacation from one's daily concerns. This may be a brief experience, as when one takes a mental break by gazing out the window, or longer, such as when one takes a walk in the woods or a week-long backpacking vacation. *Extent* is the depth or scope of the experience. An experience within which one can become immersed can be said to have extent. *Compatibility* refers to the match between the environment and one's purposes or inclinations, such that directed attention is not needed and is allowed to rest. Although in some cases non-natural experiences may contribute to the restoration of mental fatigue, these four characteristics are most commonly found in natural settings. Nature proves to be the most reliable source of mentally restorative experiences.

Summary

A pattern seems to emerge from the literature. The pattern suggests that a child living in a place with more nature, with more restorative resources is likely to benefit with respect to his or her cognitive functioning or attentional capacity.

Although studies of housing quality present a somewhat ambiguous picture of the role of physical or natural surroundings (Blackman et al. 1989; Obasanjo, 1998), research on housing type (i.e., high-rises) is clearer in this

regard. The research tells us that high-rise housing is associated with behavioral problems (Gillis, 1974; Ineichen & Hooper, 1974; Richman, 1977; Saegert, 1982), less outdoor play (Churchman & Ginsburg, 1984; BDOE, 1973; Gittus, 1976), and poor physical health (Fanning, 1967; Goodman, 1974) among children. Might these negative outcomes result from being removed from the ground and thereby deprived of the restorative benefits of the natural surroundings?

Studies of the effects of nature suggest this may be the case. There is strong and abundant evidence that experiences with nature are positively associated with well-being in its psychological (R. Kaplan, 1973; R. Kaplan & S. Kaplan, 1989; R. Kaplan & Talbot, 1988), physical (Moore, 1981; Ulrich, 1984; Verderber & Reuman, 1987; West, 1986), and cognitive aspects (Cimprich, 1990; Hartig et al., 1991; Tennessen & Cimprich, 1995). In addition, the prevalence of trees is found to promote children's play and access to adults (Taylor et al., 1998). Moreover, exposure to the natural environment is linked to better motor coordination and attentional capacities among preschool children (Grahn et al., 1997).

As we fit together the various studies, the emerging pattern suggests that nature matters to children's well-being in general, and to their attentional capacities in particular. However, these issues have received little direct study within the context of the home environment.

THE CURRENT RESEARCH

The current study explores the effects of nature on the cognitive functioning of children in low-income urban families in the context of the housing environment. The study is longitudinal: In the first phase the children lived in "poor" housing that typically has fewer natural or restorative resources, whereas the second phase occurred after the families were relocated to better housing. The study examines the children's cognitive functioning (i.e., attentional capacities) at both times and explores whether changes in cognitive functioning can be associated with changes in naturalness of the home.

METHOD

PARTICIPANTS

Seventeen children participated in this study. They all were members of low-income families who were participating in a self-help housing program,

TABLE 1
Gender and Ethnicity Summary

Ethnicity	*Girls*	*Boys*
African American	6 (35%)	5 (29%)
White	2 (12%)	4 (24%)

TABLE 2
Housing Types Prior to Relocation

Housing Type	n	*%*
Apartment	4	24
Townhouse	4	24
Single-family house	6	35
Duplex	2	12
Mobile home	1	6

through which their families helped to construct and then purchase a new home. A total of 9 boys and 8 girls participated in the study. Of these, 76% of the children (13 of 17) came from female-headed single-parent households. The majority (65%) were African American, and the remainder were White (see Table 1). They ranged in age between 7 and 12 years, with six 8-year-olds in the sample.

The families were first visited when they were residing in substandard rental apartments or houses. At that time, more than one third of the families lived in single family houses (see Table 2). Six (35%) of the 17 families resided in public housing. The next year, the families were visited again after they had resided in their new single family houses for at least 4 months (average = 7 months).

CONSTRUCTS AND MEASURES

Housing Quality: Naturalness

A detailed, objective housing scale instrument (Evans, Wells, Chan, & Saltzman, 2000) was employed both premove and postmove to assess a range of housing quality characteristics. From that instrument, a naturalness scale of the residential environment was developed. The naturalness scale consisted of 10 items regarding the amount of nature in the window view from

TABLE 3
Items in the Naturalness Scale

Area of House	*Naturalness Scale Items*
Living room	1. What is the view? 0 = *none*, 1 = *no natural*, 2 = *less than half* natural, 3 = *more than half natural*.
Kitchen	2. What is the view? 0 = *none*, 1 = *no natural*, 2 = *less than half* natural, 3 = *more than half natural*.
Bedroom	3. What is the view? 0 = *none*, 1 = *no natural*, 2 = *less than half* natural, 3 = *more than half natural*.
Outdoors	4. Yard: What material is it? 3 = *grass*, 2 = *dirt*, 1 = *concrete*, 0 = *other*.
Living room	5. How much of the view is built environment? 5 = *not at all*, 1 = *a great deal*.
Kitchen	6. How much of the view is built environment? 5 = *not at all*, 1 = *a great deal*.
Bedroom	7. How much of the view is built environment? 5 = *not at all*, 1 = *a great deal*.
Living room	8. How much of the view is natural environment? 1 = *not at all*, 5 = *a great deal*.
Kitchen	9. How much of the view is natural environment? 1 = *not at all*, 5 = *a great deal*.
Bedroom	10. How much of the view is natural environment? 1 = *not at all*, 5 = *a great deal*.

NOTE: Cronbach alphas for Restorativeness Scale for larger samples from same data sets are as follows: Premove $N = 38$, $\alpha = .43$; postmove $N = 30$, $\alpha = .46$. From a rural New York sample, $N = 283$, and, for items 1 through 4 only, $\alpha = .59$. To make items 1 through 7 more intuitive, the phrasing of responses found in previous use of the measure was reversed.

the living room, kitchen, and mother's bedroom, as well as questions about the material of the yard (see Table 3).

Children's Cognitive Functioning: Attention Deficit Disorders Evaluation Scale (ADDES)

The mothers answered a series of questions that measure children's cognitive functioning or ability to focus their attention. The ADDES, developed by McCarney (1995) and produced by Hawthorne Educational Services, Inc., consists of 46 questions to be answered by a parent regarding the child. The parent is asked to indicate how frequently the child engages in the described behavior (0 = *does not engage in the behavior*, 4 = *engages in behavior one to several times per hour*). Items include "Starts but does not complete homework," "Has accidents which are the result of impulsive or careless behavior," and "Is easily angered, annoyed, or upset." The scale yields three scores:

an inattention subscore, a hyperactivity-impulsivity subscore, and an age-based percentile score.

The ADDES is a nationally standardized instrument traditionally used as a measurement of Attention Deficit/Hyperactivity Disorder. Both the reliability and the validity of the instrument have been extensively established by its creator, McCarney (1995). Normative data were collected based on the evaluation of 2,415 children and youth 3 to 20 years old. In addition, 3,932 parents or guardians rated their children using the ADDES instrument to establish national norms.

The test-retest reliability of the ADDES was evaluated by having 148 children or youth rated using the ADDES instrument 30 days following the first rating. The test-retest reliability ranged from .88 to .93 for age categories from 4 to 6 years to 16 to 18 years. For the ages relevant to the present study the test-retest reliability for both girls and boys was .90 (7 to 9 years), .91 (10 to 12 years) and .90 (13 to 15 years). To establish the interrater reliability of the ADDES, 86 pairs of parents with equal familiarity with their child completed the ADDES regarding their child. The interrater reliability ranged from .80 to .84 for all age levels, with an average correlation of .82. In addition, the Kuder-Richardson 20 formula (Ghiselli, Campbell, & Zedeck, 1981) was used to assess the internal consistency reliability. Both the inattention and the hyperactivity-impulsivity subscales exceeded .95 (McCarney, 1995).

Content validity addresses the issue of whether an instrument appears to measure what it is intended to measure. McCarney (1995) indicated that the instrument was developed based on careful literature review to ensure content validity. He also asked diagnosticians and parents to supply descriptions of behavior they observed in their interaction with attention deficit/hyperactivity-disordered children. In addition, an earlier 53-item ADDES was field tested and then reduced to 46 items. The instrument was also validated using the American Psychiatric Association's *Diagnostic and Statistical Manual of Mental Disorders*. The construct validity of the ADDES was established with four different strategies. Factor analysis verified the existence of distinct inattention and hyperactivity/impulsivity subscales. Diagnostic validity was established by comparing the scores of a group of children without attention deficit disorder to children previously diagnosed as having attention deficit disorder. Results showed a marked difference in the scores of the two groups. To address criterion-related validity, the ADDES was compared with several parent rating scales and child behavior scales (McCarney).

In this study, the ADDES instrument is interpreted as a measure of children's ability to focus or direct their attention (i.e., directed attention capacity, or DAC). The behaviors addressed in the set of 46 questions represent

classic examples of reduced DAC (e.g., "is easily distracted," "does not direct attention," "is disorganized," "does not remain on task," "is easily frustrated," "is impulsive," "is easily angered, annoyed, or upset"). Grahn et al. (1997) used portions of the ADDES to measure children's "power of concentration" in a study of the effects of day care centers in more and less natural settings. It is also noteworthy that the ADDES percentile score used in this study is age-based, so the potentially confounding fact that the children are one year older in the second year is taken into account in the calculation.

PROCEDURE

We first visited the families in the early summer to collect premove data. One researcher sat with the child's mother in the living room or kitchen and conducted the ADDES. At the same time, a research assistant completed the objective housing quality scale that included the naturalness subscale. Prior to beginning the study, the assistant was trained on the completion of the housing scale. The following summer, after the families had resided in their new houses for several months, we visited them again, and an identical procedure was followed. The same researchers administered the ADDES and completed the housing scale both years. Note that because both the premove and the postmove interviews were conducted during the same season (summer), we would not expect seasonal differences in vegetation.

RESULTS

ARE THE NEW ENVIRONMENTS GREENER? EXAMINING PREMOVE VERSUS POSTMOVE CHANGES

The first question addressed was whether the new housing environments were greener and/or more natural than the original housing. Means were compared to determine if changes occurred in naturalness from premove to postmove. As revealed by *t*-tests, the new home environments did have significantly more natural character than the original housing (premove = 2.19, postmove = 2.46; $t\ (16) = 3.22$, $p < .01$).

EXAMINING BIVARIATE RELATIONSHIPS

To gain insight into the relationships among the variables, bivariate correlations were examined. These are presented in Table 4.

TABLE 4
Bivariate Correlations of Naturalness and Attentional Capacity Variables

	Premove DAC	*Postmove DAC*	*Premove Naturalness*	*Postmove Naturalness*
Premove DAC	1.00			
Postmove DAC	.708**	1.00		
Premove Naturalness	–.187	–.528*	1.00	
Postmove Naturalness	–.326	.098	.310	1.00

NOTE: DAC = directed attention capacity.
*$p < .05$. **$p < .01$.

The highly significant correlation ($r = .708$, $p < .01$) between premove DAC (ADDES percentile score) and postmove DAC is not surprising. Because the ADDES is a highly reliable instrument, we would expect a substantial correlation in the same children's scores from one year to the next.

Particularly striking is the lack of a significant correlation in the cross-sectional data. In other words, premove naturalness is only modestly correlated with premove DAC ($r = –.187$). It is also puzzling that this correlation is negative. Similarly, the correlation between postmove naturalness and postmove DAC is nonsignificant ($r = .098$). However, a closer look at the bivariate correlations reveals something equally striking. The naturalness of the original housing is significantly negatively correlated with DAC the following year ($r = –.528$, $p < .05$). This correlation suggests that children who lived in the least natural environments prior to relocation tend to have the highest DAC scores following the move, presumably because they experienced the most improvement (increase) in the naturalness of their environment from one year to the next. This interpretation would suggest that the change in restorativeness may be a more appropriate predictor of DAC than the absolute level. This will be examined next.

EXPLORING THE PREDICTIVE RELATIONSHIP BETWEEN NATURALNESS AND COGNITIVE FUNCTIONING

A series of hierarchical regression analyses were conducted to explore the relationship between the naturalness of the home environment and children's DAC. The dependent variable in these analyses was the children's cognitive functioning (ADDES percentile score) postmove. The corresponding score in the prior year was entered as the first independent variable to control for its effects. The change in naturalness (from the premove residence to the postmove residence) was then entered as the second predictor variable.

TABLE 5
Regression of Children's Postmove Directed Attention Capacity (DAC) Onto Premove DAC and Change in Naturalness

Predictor	*Total* R^2	ΔR^2	$F(\Delta R^2)$	df	β	SE *of* β
Premove DAC	.501**	.501	15.08**	1, 15	.579	.149
Change in Naturalness of Home	.699**	.198	9.22 **	1, 14	29.59	9.75

**$p < .01$.

TABLE 6
Regression of Children's Postmove Directed Attention Capacity (DAC) Onto Premove DAC and Change in Overall Housing Quality

Predictor	*Total* R^2	ΔR^2	$F(\Delta R^2)$	df	β	SE *of* β
Premove DAC	.501**	.501	15.08**	1, 15	.579	.149
Change in Housing Quality	.536	.035	1.06	1, 14	18.66	18.16

**$p < .01$.

Table 5 indicates that beyond the explanatory power of the premove DAC, the change in the naturalness of the home is a statistically significant predictor of the postmove attentional capacity, $F(1, 14) = 9.22$, $p < .01$. The naturalness change score explains an additional 19% of the variance in postmove attentional capacity, beyond the 50% of the variance explained by premove attentional capacity.

CONSIDERING A POTENTIAL ALTERNATIVE EXPLANATION

Although this analysis indicates that the change in naturalness from one year to the next had a profound effect on cognitive functioning of these children, there may seem to be another candidate explanatory variable. The children also experienced an improvement in housing quality. Whether this change also predicts higher levels of cognitive functioning can be addressed statistically. Hierarchical regression analyses analogous to those conducted above were conducted using change in overall housing quality as a predictor. In this case, the dependent variable is still postmove DAC and the first predictor variable is still the premove DAC score. Then, change in housing quality is entered as an explanatory variable. Table 6 indicates that beyond the explanatory power of the premove DAC, change in the overall housing quality is not a statistically significant predictor of the DAC, $F(1, 14) = 1.06$, $p =$

.321. The housing quality change score explains only 4% of the variance in the postmove ADDES score, beyond the 50% of the variance explained by premove ADDES. This finding helps to bolster our confidence in the restorative effects of the naturalness of the environment, which explained a substantial 19% of the variance beyond that explained by the premove DAC score.

DISCUSSION

THE POWER OF NATURE

This exploratory study suggests that the effects of natural elements within the home environment have a profound effect on children's cognitive functioning. Children who experienced the most improvement (increase) in the natural elements or restorative characteristics of their home tended to have the greatest ability to direct their attention several months after moving to the new home. That the change in restorativeness explains 19% of the variance in postmove DAC after controlling for premove DAC is striking, particularly considering the modest sample size of 17. These findings suggest that the power of nature is indeed profound. Furthermore, the results of this study are consistent with the findings of Grahn et al. (1997), who reported that children in a more natural day care center had greater attentional capacity than did those in less natural day care centers where they spent less time outdoors. The findings are also in accord with the substantial body of literature regarding adults that suggests that exposure to the natural environment—directly or through one's window view—is psychologically, cognitively, or physically beneficial (Hartig et al., 1991; R. Kaplan, 1973; R. Kaplan & S. Kaplan, 1989; R. Kaplan & Talbot, 1988; Moore, 1981; Tennessen & Cimprich, 1995; Ulrich, 1984; Verderber & Reuman, 1987; West, 1986).

Given that the change in vegetation seems to be so critical, and no significant cross-sectional correlations occur, we might ask whether these effects are likely to last for months and years to come. Will the children's engagement with the outdoors continue, or will they, with time, return their focus to indoor pursuits? In other words, is this a durable effect or merely a honeymoon effect? One might expect an adaptation level phenomenon to occur such that the children initially respond to the increased naturalness near their home by spending more time outdoors but then eventually settle back to indoor activities. Whereas this would likely be the case with a new toy or a superficial change to the environment, it seems to be an unlikely response to

the natural environment. In fact, according to research by Sebba (1991), when asked to name the most significant place from their childhood, adults consistently named an outdoor place. Outdoor places are also among the favorites of children, particularly boys, although these preferences seem to be influenced by the availability of natural areas (i.e., urban vs. rural). Nature, with its inexhaustible opportunities for engagement and exploration, provides an endless space for children's play and reflection. Nature is unlikely to grow tiresome.

CONCLUSIONS

This study has several strengths. One is that a trained rater evaluated the restorative character of all of the homes based on an objective set of evaluation criteria. The children's mothers rated the children's attentional capacity using a measure with established validity and reliability (ADDES). Thus, the restorativeness of the surroundings and the children's attentional capacity and cognitive functioning were each judged by independent raters. Perhaps foremost among the strengths is the longitudinal design of the study. The pre-post longitudinal design allows us to rule out the potentially confounding influence of a variety of personal characteristics such as socioeconomic status and age. In addition to the longitudinal design, the statistical analytic strategy employed in this study further bolsters our confidence about a confounding variable at work: Using a change score as a predictor variable helps to isolate the variable of interest.

FUTURE RESEARCH

Future research might employ additional measures of DAC among children. Although the ADDES appears to be a successful measure of the construct, it is an observational measure, specifically, one based on the parents' reports of the children's behavior. A performance measure or a self-report measure for children would be a valuable addition to the research and would, presumably, provide convergent validity of the DAC phenomenon among children.

The generalizability of the findings of this study is unclear. The population of interest in this study was low-income urban children between age 7 and 12. Would these findings generalize to younger children? Would they apply to older children who, as Obasanjo (1998) points out, seem to be less affected by the housing conditions because they presumably spend less time at home? In addition, this research focused on the home environment. Future

research might explore the relevance of these findings to school environments.

Research following this work and that of Grahn et al. (1997) might explore what types of play activities are most restorative for children and what environments support such play. For instance, given that "being away" (S. Kaplan & R. Kaplan, 1983) is one component of a restorative experience, perhaps play that involves make-believe or the "transformation" (Suransky, 1982) of trees into space ships, and rocks into turtles, for example, would be more restorative to children. Further research might also explore what types of landscape design would facilitate such play.

Efforts might also focus on gaining a clearer understanding of the relationships between a variety of home environment variables that influence children's behavior and well-being. One fascinating set of moderator questions to explore stems from whether the naturalness and restorative characteristics of the home environment can buffer or moderate other environmental effects on children. For instance, we know that highway noise near the home (Cohen, Glass, & Singer, 1973) or train noise near the classroom (Bronzaft & McCarthy, 1975) interferes with children's learning to read. Might natural elements help to buffer such an effect? Likewise, research shows that residential crowding increases tension between parents and children (Evans et al., 1998). Can nature in the home environment moderate such effects? Also, if children living on the higher floors of high-rises tend to play outside less often (BDOE, 1973), and outdoor spaces with trees and vegetation surrounding public housing buildings are used by both children and adults more than the barren spaces (Coley et al., 1997), might the presence of trees moderate the effects of living on the higher floors of a high-rise building? Or might the trees only make a difference for the residents who live closer to the ground? Answers to such questions could have considerable implications with respect to the design of residential environments.

Furthermore, it would also be valuable to tease apart the role of the restorativeness of the home environment as measured in this study from the interior (i.e., view from window) from the role of interacting with outdoor vegetation by spending time outside. One might hypothesize that outdoor vegetation plays multiple beneficial roles for children. First, by providing a green view, it contributes to the restoration of attentional capacities. Second, by drawing people outside, vegetation may further contribute to the restoration of attention as well as to play behavior and connection to adults as Coley et al. (1997) described. The distinction between these two benefits may not be trivial.

IMPLICATIONS

The results of this study suggest that the natural environment may play a far more significant role in the well-being of children within a housing environment than has previously been recognized. Studies of housing dating back to the 1970s have attributed differences in behavior, physical health, and mental health to differences in housing quality or housing type but have largely neglected to consider the potential contribution of the surrounding (or out-the-window) nature.

These findings are particularly relevant to impoverished urban children who face a host of social, economic, and environmental disadvantages. To recognize characteristics in the physical environment that might make a difference in the lives of children can provide valuable insights for policy makers, public housing authorities, architects, and planners, enabling them to make a difference. Perhaps architectural features such as porches or large windows provide a connection between interior and exterior spaces and thereby facilitate people's use of outdoor spaces. Remarkably simple interventions such as preserving existing trees when homes are constructed, orchestrating tree-planting efforts in urban neighborhoods, or incorporating grass areas in housing complexes may have a significant impact on children's welfare. Small differences accumulate into big differences and provide ways for children to overcome disadvantage.

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