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The Restorative Effects of Redesigning the Schoolyard: A Multi-Methodological, Quasi-Experimental Study in Rural Austrian Middle Schools

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Abstract

Contact with nature can have numerous beneficial effects for children. As the school is a place where children spend a lot of time, the physical environment of the school has considerable potential to influence children. This study investigated the influence of a redesign (greening) of a schoolyard on pupils' physiological stress, psychological well-being, and executive functioning. A pre–post, quasi-experimental design with a multimethod approach was applied. One-hundred thirty-three middle school pupils (M = 14.4 years) of three middle schools in a rural area in Austria were assessed. The renovated schoolyard significantly diminished pupils' physiological stress levels and enhanced their psychological well-being. Pupils in the renovated schoolyard setting also perceived the environment as more restorative following the redesign. However, it did not affect executive functioning as hypothesized. Limitations of the study and future research opportunities are discussed.

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quasi-experiment/field study, research methods, stress, content areas, children, research setting/place type, natural environments, restorativeness

Introduction

Humans prefer wild and landscaped nature over built environments (Van den Berg, Hartig, & Staats, 2007). Studies concentrating on children find that environments predominated by natural features are valued most (Elsley, 2004; Korpela, 2002; Loukaitou-Sideris, 2003). Furthermore, outdoor public spaces providing trees and vegetation are used more frequently by adults and adolescents than are spaces without those features (Coley, Kuo, & Sullivan, 1997). Findings on humans' general preference for nature and greenery imply that exposure to green environments has beneficial effects on humans' restoration, well-being, and health (Wells & Evans, 2003), given that the restorative potential of environments probably depends on people liking the environment (Hartig & Evans, 1993).

Restoration can be defined as the process of renewing diminished functional resources and capabilities. Multiple processes are involved during restoration that include positive shifts in mood, declines in physiological stress, and improved task performance, particularly in measures of executive functioning such as attention and working memory (Hartig & Staats, 2003). R. Kaplan and Kaplan (1989) suggest that natural environments are frequently restorative because they help replenish attention after mental fatigue, which develops after prolonged use of directed attention. Directed or voluntary attention requires mental effort by forcing oneself to pay attention to something that is not particularly interesting (S. Kaplan & Berman, 2010). Four major components of restorative environments include being away, fascination, extent, and compatibility (R. Kaplan, 1995). Being away refers to the experience of not only being in a different surrounding but also having the feeling that one can escape from unwanted distractions in the surroundings, distancing oneself from one's daily routine, and reminders of it, and suspending the pursuit of particular purposes. Fascination is said to be the counterpart to directed attention in terms of effort. Natural environments like clouds, sunsets, and moving leaves hold "soft fascination" that do not require effort, and thus provide the opportunity to think about other issues. A sense of extent is encouraged by natural environments that relates to the coherence in the experience of the environment, and the scope for continued exploration. Compatibility, finally, is the degree to which the affordances and requirements of the environment match and support the person's goals and inclinations (R. Kaplan, 1995).

Another important perspective on restoration is provided by psycho-evolutionary theory (Ulrich, 1983). Due to the fact that humans evolved in natural environments over a long period, people may be better adapted to natural than to urban settings. In this biophilic theory, restoration applies to a broader context than does attentional capacity and can happen even when directed attention is not fatigued.

Experiments and field studies demonstrate positive physiological, mental health, and cognitive effects of exposure to natural settings. For instance, heart rate in subjects watching a video with natural scenes was significantly lower than in those watching a video depicting urban scenes (Laumann, Gärling, & Stormark, 2003). Sitting in a room with a nature view after a stressful task was found to cause a decline in blood pressure while blood pressure in participants sitting in a room with no view increased (Hartig, Evans, Jammer, Davis, & Gärling, 2003). Participants then had to go for a walk either in a forest where their blood pressure further decreased or in an urban environment, which caused a further increase in blood pressure. In another study comparing the effects of natural versus urban scenes on restoration, a quicker recovery from physiological stress was found in natural compared with urban settings (Parsons, Tassinary, Ulrich, Hebl, & Grossman-Alexander, 1998).

Prolonged and shortened periods of interaction with nature (simulated or actual) are conducive to overall well-being assessed by affective self-reports (Hartig, Mang, & Evans, 1991). A significantly higher overall happiness was found for participants after a 40-min walk through a natural environment compared with those walking through an urban environment (Hartig et al., 2003). In addition, positive affect increased in the natural but decreased in the urban environment. Furthermore, feelings of anger and aggressiveness decreased in the natural but increased in the urban setting. Ulrich found in several studies that exposure to simulated natural settings increased well-being (Ulrich, 1979, 1981; Ulrich et al., 1991).

Beyond the positive effects on physical health and psychological well-being, natural settings can also benefit cognitive functioning. For instance, walking in nature or only viewing it improved directed-attention capabilities and short-term memory compared with walking in or viewing urban environments (Berman, Jonides, & Kaplan, 2008). Having a more natural view from a window improved directed attention when performing tasks in front of the window in comparison with a view with less nature (Tennessen & Cimprich, 1995). People watching a video of a forested area performed better in a concentration test than did people watching urban environments (Van den Berg, Koole, & Van der Wulp, 2003). Natural views from classrooms increased pupils' stimulation, decreased boredom, and were associated with better performance on tasks requiring focus and attention than was true of performance in classrooms without natural views (Eberhard, 2009). Children moving from urban areas to greener ones were found to have a greater ability to direct their attention than did children staying in the same, less natural area (Wells, 2000).

A children's schoolyard has the potential to be a place where students can experience restorative elements. The Boston schoolyard initiative renovated several deteriorated schoolyards during the mid 1990s. Lopez, Campbell, and Jennings (2008) took advantage of this natural experience because approximately half of the schoolyards were being changed while the other half remained unchanged. They found positive effects of these improvements on standardized test scores among school children. In another study, schools offering a lawn in the schoolyard were compared with schools that did not have a lawn (Tanabe, Mishima, & Fujii, 2005). Pupils in the "lawn schools" played, romped, and rested more by having a greater variety in these actions than did pupils in schools without lawns. In a newly emerging literature on the effects of schoolyard design, a meta-analysis revealed benefits of green schoolyards including increased play opportunities, enhanced social relations among pupils and teachers, heightened environmental concern, increased learning opportunities, improved academic performance, enhanced physical activity, and better physical and mental health (Bell & Dyment, 2008).

Schoolyards can be a primary source for positive nature experiences during childhood (Herrington & Studtmann, 1998). As opportunities for contact with nature decrease in our modern society and sedentary leisure time activities (e.g., playing video games) increase, there is a need for restorative outdoor environments for children.

In contrast to artificial experimental studies, this one capitalized on a naturalistic experiment afforded by the holistic renovation of the outdoor play space of a middle school. The renovation focused on enhancing opportunities for contact with nature and opportunities for physical activities. We assessed changes in the restorative potential of the space, before and after, and collected data on multiple indicators of well-being. Parallel data were collected at two nearby schools over the same time period.

From the literature, we can conclude that physiological stress reduction, better well-being, and enhanced executive functioning are potentially beneficial outcomes of more contact by children with greener schoolyards proximate to their schools. For example, Matsuoka and Kaplan (2008) list several studies showing the pervasive need for restorative experiences in nature across the age spectrum. To empirically test this idea, we conducted a quasi-experiment comparing two groups of schools over time. Children at one school were monitored before and after the construction of a green school yard. Children at two comparison schools were measured over the same period of time but without any changes in their school yards. With this research design, we tested the following directional hypotheses assuming that the two groups of schools did not differ in initial values on the dependent outcomes at the time of the pre-construction measurement:

1. Physiological stress (blood pressure and heart rate) will be significantly reduced at the second time of measurement only in the group having received a greener schoolyard.
2. Cognitive executive functioning will be significantly enhanced at the second time of measurement only in the group having received a greener schoolyard.
3. Well-being will be significantly improved at the second time of measurement only in the group having received a greener schoolyard.
4. The new, green schoolyard will be perceived as more restorative than the old one at the intervention school.

The current study used a multimethod approach using indicators of physiological stress, psychological well-being, and cognitive executive functioning to obtain a more holistic picture than prior studies, which have typically examined only one facet of redesigning schoolyards. Furthermore, we provide a quasi-experimental research design that enables us to evaluate how changes in restorative properties of a setting may influence these multiple outcomes.

Method

Design

The study was a pre-test/post-test quasi-experimental field research. The first independent variable, time, incorporated measurements before and after renovation of the schoolyard. The second independent variable was the schoolyard; the experimental school had its schoolyard renovated whereas no schoolyard changes were made in two comparison schools. Outcome variables were blood pressure, executive functioning, and psychological well-being. We also included a standardized index of perceived restoration to evaluate whether or not the attempt to enhance the restorative potential of the renovated schoolyard was successful.

Participants

From a total of 195 pupils tested, we had had complete data sets from both test sessions for 133 pupils. Those were used for statistical analyses. From the remaining participants, 72 (49% female) came from the experimental school and 61 (48% female) from the control schools of which 27 came from control school A (41% female) and 34 came from control school B (50% female). For this study, all fourth-grade pupils (13-15 years of age) were chosen. All schools were located on the same street of a small city of 5,000 inhabitants in Austria. The experimental school was a Gymnasium (secondary school) with pupils from 10 to 18 years old. The control schools were both "Hauptschulen" (secondary modern schools) that have an age range from 10 to 15 years. For this study, all fourth grade pupils were chosen, all between 13 and 15 years old. The main difference between the two groups was the school type. Usually a "Gymnasium" is more academically challenging than a "Hauptschule"; pupils in a "Gymnasium" tend to have higher levels of academic achievement than do those in the "Hauptschule." However, in both schools the curricula are similar during the first 4 years. All our participants were still in these similar curricula. To check if the groups were comparable prior to the construction of the greener outdoor playspace, the distribution of demographic variables was compared between the two groups. Percent male, size of hometown, height, weight, amount of greenery near their homes, time spent outdoors, and involvement in sports activities were all comparable between the two groups. For the assessment of these variables, please refer to the "Demographic variables" section. Father's highest education level, $\chi^2(df = 4) = 9.55$, $p = .049$, and mother's highest education level $\chi^2(df = 4) = 22.89$, $p = .001$, were significantly greater in the experimental versus the two comparison schools. Therefore, we tested for the influence of mother's and father's highest education on each dependent variable but found no significant effects on either of these.

Material

Physiological stress. As indicators for pupils' physiological stress, blood pressure was measured with blood pressure measurement devices from BOSO (medistar-S, see http://www.boso.de/Blutdruckmessgeraete-fuer-Patien.16.0.html). Resting blood pressure was calculated using the same procedure as Llabre et al. (2007): We took seven readings of systolic and diastolic blood pressure at rest and excluded the first reading from the analysis to get a reliable mean value for resting blood pressure of each person.

Executive functioning. To determine executive functioning, the Attention Network Test (ANT; Fan, McCandliss, Sommer, Raz, & Posner, 2002) was used. The ANT is a computer-based reaction time test in which participants respond to the direction of a centrally presented arrow. The test either shows one or five arrows. If there are five arrows, the subject has to respond to the arrow in the middle (target arrow). The middle arrow either points in the same direction (congruent condition) as the flanking arrows or in the opposite direction (incongruent condition). The test yields three indicators called the alerting score, the orienting score, and the conflict score. The conflict score is calculated by contrasting the incongruent condition trials with the congruent condition trials and is the principal index of Executive Functioning and is measured in milliseconds (higher values indicate worse executive functioning). Thus, the Conflict scale was used herein.

Well-being. The Basler Well-Being Questionnaire (Basler Befindlichkeitsskala [BBS]; Hobi, 1985; Juda, 2010) is a standardized, German questionnaire to assess current well-being and is divided into four factors (vitality, vigility, social extroversion, intra-psychic balance). We used the intra-psychic balance subscale as one index of well-being. Respondents indicated the extent to which statements describe how they feel that moment on a 7-point scale between two bipolar adjectives (e.g., Right now, I feel calm….nervous). As a second index of well-being, the Recovery-Stress Questionnaire (R-SQ; Kallus, 1995) was used to determine pupils' recovery from stress. This questionnaire is behavior-based and asks for the frequency of situations that had happened during the last 3 days (e.g., During the last 3 days/nights . . . I was in a good mood). Answers are given on a 7-point scale, ranging from "never" to "all the time."

Perceived restorativeness. The Perceived Restorativeness Scale (PRS; Hartig, Korpela, Evans, & Gärling, 1996) was used to determine the subjective impression of the restorative qualities of the schoolyard before and after the renovation. It assesses four scales: being away, fascination, coherence, and compatibility, which are all based on the Attention Restoration Theory from R. Kaplan and Kaplan (1989, 1995). Note this scale was only given to the experimental school to measure whether the construction of a new, greener outdoor space would be perceived as more restorative by the children themselves.

Demographic variables. Demographic variables were assessed with the following questions:

- "Approximately how often per week do you do any sports (apart from PE lessons)?" Answers format ranged from 1 = "never" to 3 = "3 times or more often."
- "Approximately how often per week do you go outdoors into nature?" Answer options were the same as for the first question.

- Moreover, for assessing the nature near home, participants were asked to draw their window view from the room they spend the most time in when being at home and label all objects within the drawing. From the drawings, we calculated the ratio of "nature" compared with non-nature.
- "The place I live in has less than . . . " Answers were to be given in the following categories: 500 inhabitants/500-999 inhabitants/1,000-9,999 inhabitants/10,000 or more inhabitants.
- My dad has finished compulsory school/junior high school/secondary school/apprenticeship/college.
- My mom has finished compulsory school/junior high school/secondary school/apprenticeship/college.

Settings

The experimental school in which the schoolyard was renovated is located in Gleisdorf, a village with approximately 5,000 inhabitants in Austria. The schoolyard is approximately 1,128 square meters (24 × 47 meters). The schoolyard is surrounded by the school building like a courtyard. The original schoolyard provided little exposure to greenery.

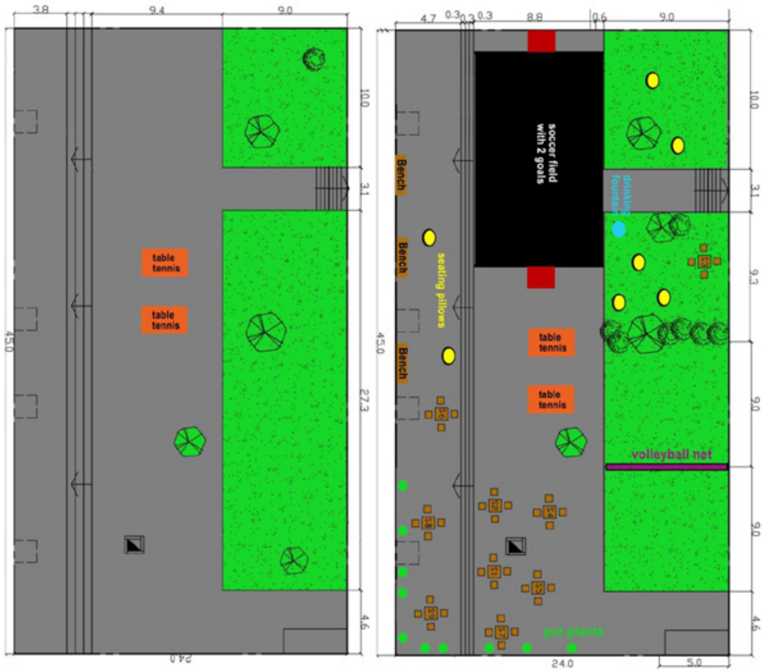
The two control schools are both located nearby on the same street in Gleisdorf that is located in the periphery of the village. The amount of greenery in the surroundings of all schools is high. The control school A does not have a designated schoolyard but some pupils spend breaks outdoors at the entrance area, which also offers some trees and benches to sit on. The control school B provides an outdoor area for its pupils offering some seating options on a lawn interspersed with trees and shrubs. Compared with the experimental school, this outdoor area is not enclosed by the school building.

The design for the new schoolyard of the experimental school was based on findings on restorative environments. The following Figure 1 shows the comparison of the schoolyard before and after renovation.

As can be seen from Figure 1, more greenery (a hedge consisting of 10 shrubs and 10 pot plants around the seating area) was implemented in the schoolyard along with enhanced seating (9 wooden tables and chairs, 3 wooden benches as well as 15 seating pillows), sports opportunities (2 soccer goals and field markings, 2 table tennis tables, 1 volleyball net), and a drinking fountain.

Procedure

The first data collection (baseline) was performed a month before the installation of the new schoolyard in March 2009. The pupils of all participating



Features BEFORE renovation	Features AFTER renovation
Greening	
no shrubs no pot plants	10 shrubs 10 pot plants
Seating	
no seating options	9 wooden chairs and tables 3 wooden benches 20 cotton seating pillows
Sporting features	
2 table tennis tables	2 table tennis tables 1 volleyball net and field 2 soccer goals with field markings
Water	
no refreshment options	1 drinking fountain

Figure 1. Schoolyard of the experimental school before and after renovation, listing features installed.

schools were measured in groups of 20 in a computer room with no view to the schoolyard, which was located in the experimental school. The complete test session lasted for approximately 50 min, which matches the duration of one classroom session. The same two adult experimenters conducted all pupils' assessments. At the beginning of the test session, pupils completed the questionnaires. After all pupils had finished, the ANT was performed. To evaluate whether the renovation of the schoolyard in the experimental school enhanced restoration, children at the experimental school were also given the PRS (Hartig et al., 1996). In between pupils' blood pressure was measured while seated quietly every 7 min. The schoolyard was installed during the first two weeks of May 2009 and the second data collection was performed at the end of June, so that pupils had been exposed to the new schoolyard for approximately 6-7 weeks. Day of week and time of day were held constant for each test session over both data collections.

Statistical Analysis

To test the Hypotheses 1 through 3 of this study, planned comparisons were used to contrast the experimental school's pupils' mean of the second measurement (after schoolyard installation) against the mean of the other three means (both measurements of control school's pupils and first measurement of experimental school's pupils). See Kirk (1982) for more information on using planned comparisons to test for prior, hypothesized interaction effects.

Hypothesis 4 was tested using a *t* test for paired samples because the perceived restorative scale was only completed in the experimental school before and after the schoolyard renovation.

Results

Physiological Stress

Physiological stress was measured using blood pressure that was measured seven times during the test sessions (Llabre et al., 2007). For statistical analyses, systolic blood pressure values below 70 and above 200 mmHg and diastolic blood pressure values below 40 and above 120 mmHg were excluded. These outliers were identified by boxplots. Significant effects were found for diastolic blood pressure, $F(1, 184.3) = 15.46$, $p = .001$, $d = .41$, and systolic blood pressure, $F(1, 175.4) = 5.14$, $p = .025$, $d = .23$. Values for systolic and diastolic blood pressure are depicted in Table 1. Figure 2 further illustrates the findings for systolic blood pressure and exemplifies the pattern of results found for the other dependent variables (diastolic blood pressure, executive functioning, and the two different well-being measures).

As can be seen from Figure 2 and Table 1, the mean values of the physiological stress indicators were lower for the experimental school's pupils at the second time of measurement compared with the mean of both times of the control school's measurements and the experimental school's first time of measurement.

Table 1. Mean Scores (*M*) and Standard Deviations (*SD*) of the Significant Findings Found in Physiological Stress, Executive Functioning, and Well-Being.

	Test school		Control school	
	Pre	Post	Pre	Post
Measure	M (SD)	M (SD)	M (SD)	M (SD)
Indicators for physiological stress				
Diastolic blood pressure (mmHg)	66.38 (8.21)	63.25 (8.54)	66.56 (8.35)	64.71 (7.80)
Systolic blood pressure (mmHg)	108.17 (9.33)	106.83 (8.93)	108.53 (9.18)	108.89 (9.06)
Indicator for executive functioning				
Conflict score (ANT, milliseconds)	137.25 (42.25)	104.79 (34.61)	165.14 (65.74)	114.00 (33.58)
Indicators for well-being				
Intra-psychic balance (BBS)	5.20 (1.01)	5.60 (0.88)	5.38 (1.00)	5.30 (1.15)
Overall well-being (R-SQ)	3.70 (0.82)	3.90 (0.74)	3.86 (0.81)	3.71 (0.89)
Indicators for perceived restorativeness				
Being away (PRS)[a]	2.73 (1.37)	2.96 (1.50)		
Fascination (PRS)	2.96 (1.50)	3.31 (1.41)		
Coherence (PRS)	4.57 (0.65)	4.23 (1.00)		
Compatibility (PRS)	2.47 (1.31)	3.10 (1.31)		

Note. ANT = Attention Network Test; BBS = Basler Befindlichkeitsskala; R-SQ = Recovery-Stress Questionnaire; PRS = perceived restorativeness.
[a]No significant differences between these means.

Executive Functioning

For this analysis, 24 pupils (15 from control schools and 9 from experimental school) had to be excluded as they had not finished the test or had less than 70% accuracy. Reaction time data cannot be interpreted in the presence of a high error rate and 70% accuracy is recommended as the minimum required (Berman et al., 2008; Fan et al., 2002). No significant results were found using planned contrasts to test the hypothesized beneficial effects of the schoolyard renovation on executive functioning. Further exploration of the data, however, revealed a significant interaction, $F(1, 104) = 4.74$, $p = .032$, $\eta_p = .044$, using a two-way mixed ANOVA with group as the between-subject factor (test vs. control school) and time of measurement as the within-subject factor. Post hoc analyses revealed a significant increase in executive functioning scores from pre- to post-measurement in the test school, $t(62) = 6.74$,

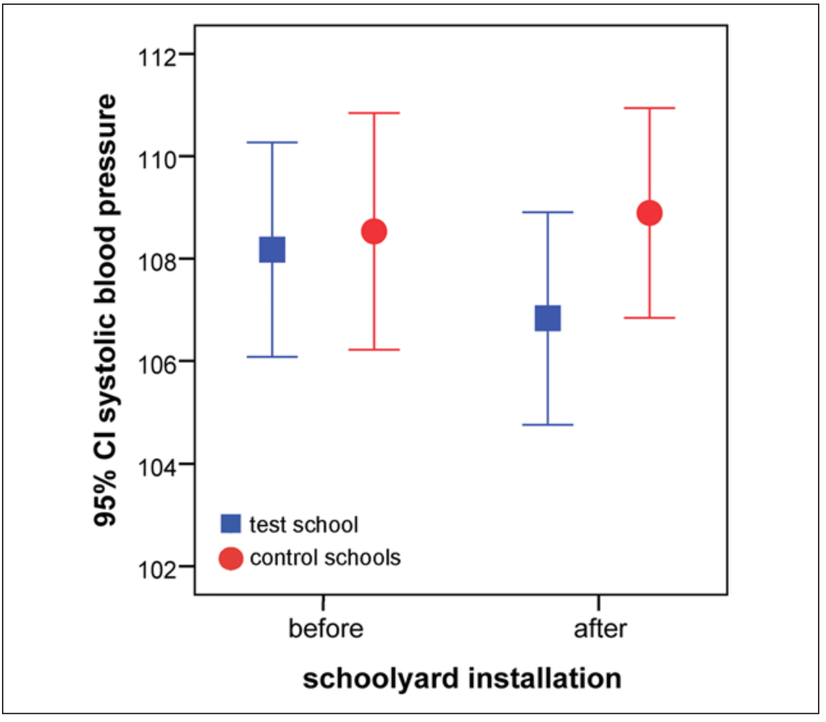


Figure 2. Changes of systolic blood pressure from pre- to post-installation of the schoolyard in both groups.

p = .001, d = .85, and the control schools, $t(42)$ = 6.71, p = .001, d = .90. Between schools a significant difference was found for the first time of measurement, $t(65.5) = -2.46$, p = .017, d = .51, but not the second time of measurement, $t(104) = -1.36$, p = .176, d = .30. These results suggest that executive functioning increased in both groups from first to second time of measurement. In addition, prior to the intervention executive functioning was significantly higher in the experimental school.

Well-Being

For intra-psychic balance, pupils from the school had significantly higher scores after the installation of the schoolyard compared with the mean of both times of measurement at the control school and the first time of measurement at the experimental school, $F(1, 190.3) = 7.63$, p = .006, d = .31. Comparable, marginal results were found for the overall well-being score based on the Recovery-Stress Questionnaire, $F(1, 172.3) = 3.78$, $p = .053$, $d = 0.18$ (see Table 1).

Perceived Restorativeness

The PRS was only used in the experimental school because only that school underwent changes predicted to influence perceived restorativeness. Thus, the change in restorative quality of the schoolyard before and after renovation was compared using a within subjects pre–post comparison. For two of the four subscales, perceived restoration increased pre- to post-renovation: For compatibility, $t(62) = 3.86$, $p = .001$, $d = .48$, values significantly increased. For fascination, $t(72) = 1.78$, $p = .080$, $d = 0.24$, a slight tendency of increase could be found. Being away did not show significant differences in the planned comparison analyses, $t(72) = 1.22$, $p = .227$, $d = .16$. Coherence, however, significantly dropped from pre- to post-renovation, $t(62) = 2.29$, $p = .025$, $d = .41$. Degrees of freedom differ between the subscales because of missing data.

Discussion

The aim of this study was to capitalize on a naturally occurring experiment to test whether the new design of the schoolyard increased restorative potential and had expected positive impacts on children's physiological stress, executive functioning, and psychological well-being. As opportunities for contact with nature diminish in modern life, the schoolyard becomes one of the primary opportunities for contact with nature for children (Herrington & Studtmann, 1998).

Our principal hypotheses were that the new design of the schoolyard would reduce physiological stress, improve executive functioning, and enhance pupil's well-being. We found support for the first and third prediction. As shown in Figure 2, blood pressure declined among students in the experimental school pre- to post-intervention whereas students in the control schools maintained or slightly increased in physiological stress over the same time period. This pattern of findings converges with prior studies of adults revealing reductions in physiological stress when exposed to nature (Hartig et al., 2003; Laumann et al., 2003; Parsons et al., 1998). Considering our young and healthy sample of pupils, the reduction in blood pressure is potent support for our hypothesis.

Concerning our hypothesis on executive functioning, we did not find supporting results. Executive functioning increased for both groups from the pre- to the post-test that may be due to learning effects. Furthermore, the experimental school's executive functioning was better than the control group at the measurement prior to the intervention. This finding could be explained by the fact that the experimental school usually has attendants of higher cognitive capacities. Further studies using cognitive indicators like the ANT should carefully choose a control group of comparable cognitive abilities. In line with this finding, Berman et al. (2008) also found an increase in executive functioning for people looking at pictures of nature compared with people looking at urban pictures. However, we found this effect for both groups, which makes it impossible to attribute the increase in executive functioning to the intervention. The results are more likely caused by interfering effects like learning and school type. Moreover, variability of executive functioning scores was very high in both samples but especially in the control school at the first time of measurement that may be due to strong differences in the developmental level of this age group.

As hypothesized, we also found enhanced psychological well-being among students in the experimental school after the renovation compared with pre-renovation and the two control schools. As shown in Table 1, experimental school pupils' psychological well-being increased from the first to the second time of measurement compared with the control school pupils whose well-being remained constant or slightly decreased. It speaks to our hypothesis that the increase of well-being was found on two different scales (the BBS and the Recovery-Stress Questionnaire). While the BBS asks for the current well-being state, the Recovery-Stress Questionnaire asks for situations of experiencing good mood during the preceding three days and nights. Our quasi-experimental results among adolescents compare favorably with prior field studies and laboratory experiments with adults indicating enhanced happiness and well-being among those exposed to nature (Hartig et al., 1991, 2003; Ulrich, 1979, 1981; Ulrich et al., 1991).

Moreover, we found some evidence that the redesign of the schoolyard partly enhanced perceived restoration, which is most likely attributable to greening the schoolyard. Fascination and compatibility increased from before to after the renovation. Being away did not change, which makes sense, because the location of the schoolyard remained in the middle of the school complex and therefore inhibited a feeling of being away. We expected but did not find an increase but instead found a decrease in coherence in reaction to the redesign of the schoolyard. One possible explanation for reduction in coherence might be the increased amount of variety or complexity within the schoolyard. The original schoolyard was a medium sized, empty area consisting largely of concrete surfaces having the same appearance as the surrounding building. The new schoolyard introduced a much greater variety of textures and features, like shrubs, pot plants, trees, sporting equipment, and several different seating opportunities. More wood and other materials were also introduced in the furniture. Thus, the decrease in coherence could be interpreted as a positive increase from minimal to medium levels of complexity. Moderate levels of complexity heighten preference for landscapes (e.g., R. Kaplan, 1995; Wohlwill, 1966). This explanation is obviously post hoc and warrants further investigation.

Some of the apparent beneficial impact of the schoolyards' redesign might also be caused by the addition of more sports equipment. We believe, however, that this is unlikely for several reasons. One, anecdotal reports and informal observations indicate that the level of physical activity did not change much in this space. Students used the new equipment but their overall level of activities remained similar. Two, the sports equipment was used predominantly by boys yet the beneficial effects were similar for both genders. Three, when asked about the schoolyard, the youth focused primarily on the changes in nature compared with concrete and said little about sports equipment. Nonetheless, ideally one would isolate these two variables from one another in a future quasi-experimental field study. Apart from greenery, and sporting features, new seating opportunities were added. The beneficial results could therefore be caused by all three kinds of improvements. However, considering the literature, strongest impacts were expected to be caused by the increase in greenery.

Another possibility as in most quasi-experimental field studies is that the intervention includes not only changes in the physical environment, but also involves a process of change itself. For example, students were asked about their likes and dislikes of their original schoolyard. Perhaps some of the benefits from the intervention reflect a student researcher making such inquiries. On the other hand, these questions did not appear to affect their pre-intervention data, which was equivalent between experimental and control schools. Moreover, it seems somewhat unlikely that the effect of a single inquiry by a researcher would persist over a 6-month period.

Limitations of the Current Study

There are three major limitations that need to be acknowledged with respect to the current study. The first limitation is the fact that the experimental school and control schools were two different school types. While the experimental school was a secondary school ("Gymnasium"), the control schools were secondary modern schools ("Hauptschule"). While pupils need to fulfill requirements concerning their final grades from elementary school to enter secondary school, anybody can attend a secondary modern school. In our sample we did find a difference in the education level of the parents, but parental education was unrelated to physiological stress, executive functioning, or psychological well-being among the students. Nevertheless, a difference was found in executive function at the first time of measurement, which perhaps speaks for better cognitive abilities in the test schools. The second limitation was the measurement periods. The first test session was performed in March at the beginning of the summer term and the second measurement wave was done in June at the end of the summer term/school year. Ideally, the second time of measurement would occur exactly a year after the first one to avoid influences of seasonal climatic and school-related influences. The weather change from March to June could have influenced the usage of the schoolyard and pupils may have spent more time outdoors in general and benefitted from that. Yet the results show that only the experimental school's pupils and not the control school pupils manifested improvements in blood pressure and well-being although pupils of all schools spent the same amount of time per day outside. In all schools the longest break is from 10:10-10:30 during which they are encouraged to spend time outside, and most of them do. Furthermore, the weather was exactly the same for all schools over the test period, because they are all located in the same street of one city. So, pupils would have spent a similar amount of time outside during the testing period in all schools, which supports our claim, that the effects found are likely based on the change in the playground environment rather than the weather.

Finally, the renovated schoolyard could be considered a "weak" treatment effect in that the degree of designed landscaping had to be curtailed because of financial constraints. In this study the intention was to make the schoolyard distinctly greener but as can be seen in Figure 1 the degree of greening of the schoolyard was rather modest. Due to financial restrictions only a few more shrubs and trees were planted, some pot plants were placed on the schoolyard, and the major material of new furniture was wood. Consequently, the difference in terms of greenery between the old and the new schoolyard may have been too small to have an even higher impact on pupils. The overall appearance of the schoolyard does still offer a lot more concrete than nature. Of course on the other hand, this speaks to the potential power of introducing nature into areas nearby children that are largely bereft of greenery. In this respect, our findings are in accord with work by Faber–Taylor and her colleagues in the Chicago public housing projects (Faber Taylor, Kuo, & Sullivan, 2001). They found that very modest amounts of grass and trees relative to largely paved outdoor areas led to various restorative outcomes. Despite the limitations mentioned above, the study has several strengths. One is that a control group was used which is an advantage compared with most environment evaluations that are simple case studies. Moreover, the longitudinal pre–post design is a potent aspect of the study as it rules out a number of confounding demographic differences and the statistical analysis gains power. Moreover, because all pupils from the selected age group were willing to participate initially and only 30% of the data sets had to be excluded due to either missing data or outliers, a very high percentage of the population of the schools' 13- to 15-year-olds was reached.

Outlook and Future Research

Despite these limitations, the study has some potentially important implications for policy, design, and research methodology. Middle schools in Austria have recently undergone a transformation process regarding timetables. Before the transformation, pupils spent 6 days a week in school, having the afternoons off. Now, there are five school days a week and a school day lasts until the early evening. This change has had a significant impact on pupils' lifestyles, limiting the opportunities for nature contact in leisure time and thus increasing the importance of school environments for quality nature experiences. This study makes the case that such quality environments benefit pupils. Therefore, it is the responsibility of school authorities and designers of school environments to provide pupils with proximate access to natural, outdoor recreation spaces.

As this study was done with a sample of 13- to 15-year-olds in a secondary school in a small Austrian village, its generalizability is unclear. The efficiency of similar interventions could be tested for all ages of school children, ranging from 6 to 18 years and all kind of school types. Moreover, research schools in more urban areas than these would be of interest. The children of this study lived in homes surrounded by nature or had easy access to nature. One would expect stronger effects of greening a schoolyard in an urban area where children are lacking contact with nature.

In this study, the experimental school had only one area for the children to play outside during breaks. Schools that have more space available or that are newly built and allow for a greater separation of areas for younger children and older children and perhaps even teachers may further enhance the usage and the beneficial impacts on the users. Teachers have stressful jobs (Abel & Sewell, 1999) and nearby outdoor recreation areas might benefit them as well, particularly if such an area were designated for their exclusive use to unwind away from students.

Aside from the measurements performed, observational data collection would have been a useful additional method, which would be very interesting to do in future studies. Furthermore, future studies should assess perceived restorativeness in all subgroups and could examine social interactions. Restorative environments may also enhance social networks and diminish aggression (Coley et al., 1997). Another interesting research question might be potential carry over effects of enhanced school environment setting to pupils' behavior outside school. For example, parental reports of their children's behavior could be examined. Finally, research could investigate whether redesigning schoolyards can impact academic performance.

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